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HIGHLIGHTS 89/1

NORTH ATLANTIC TREATY ORGANIZATION

AGARD HIGHLIGHTS 89/1

MARCH 1989

Front Cover:

The civil version of the CN-235 twin turboprop regional transport aircraft produced by C.A.S.A. in Spain; it carries 44 passengers plus baggage. There are also cargo and military versions. A description of C.A.S.A.'s R&D activities, by the president of C.A.S.A., is given on page 24.

MISSION

According to its Charter, the mission of AGARD is to bring together the leading personalities of the NATO nations in the fields of science and technology relating to aerospace for the following purposes:

– Recommending effective ways for the member nations to use their research and development capabilities for the common benefit of the NATO community;

– Providing scientific and technical advice and assistance to the Military Committee in the field of aerospace research and development (with particular regard to its military application);

– Continuously stimulating advances in the aerospace sciences relevant to strengthening the common defence posture;

– Improving the co-operation among member nations in aerospace research and development;

– Exchange of scientific and technical information;

– Providing assistance to member nations for the purpose of increasing their scientific and technical potential;

– Rendering scientific and technical assistance, as requested, to other NATO bodies and to member nations in connection with research and development problems in the aerospace field.

The highest authority within AGARD is the National Delegates Board consisting of officially appointed senior representatives from each member nation. The mission of AGARD is carried out through the Panels which are composed of experts appointed by the National Delegates, the Consultant and Exchange Programme and the Aerospace Applications Studies Programme. The results of AGARD work are reported to the member nations and the NATO Authorities through the AGARD series of publications of which this is one.

Participation in AGARD activities is by invitation only and is normally limited to citizens of the NATO nations.

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All members of AGARD, whether National Delegates, Panel Members or AGARD Staff, are cordially invited to submit letters, photographs, or articles likely to be of interest to other AGARD members for the next issue of AGARD HIGHLIGHTS which will appear in the Autumn of 1989. Material should be addressed to:

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A Note from the Director...

At exactly 0.00 hours on 1 January 1989 a huge display of lights was illuminated on the Eiffel Tower which read "100 ANS", to celebrate its inauguration one hundred years ago. On the same day a replica of a Montgolfier balloon was on display at the Jardin des Tuileries in Paris to initiate the year of the 200th anniversary of the French Revolution. The balloon is used here to symbolise LIBERTY. A very fine gesture to the aeronautical world. In AGARD-NATO terms this is even more meaningful: flight — the symbol of freedom, and also flight — the symbol of the defence of freedom.

In this 37th year of AGARD there is again a challenging and technically exciting programme to be carried out. Over the years the content of the programme has changed and it has expanded considerably, but the spirit of cooperation in AGARD is the same. Since the beginning in 1952, AGARD has become an indispensable resource of the aeronautical community of the Alliance. The new edition of "The AGARD History, 1952—1988", available this Spring, is a valuable record of the of the development of this spirit of cooperation. It makes very worthwhile reading for all who are interested in AGARD and the history of aerospace.

Most often we think about AGARD in terms of a resource for military and civilian goals and applications. However, it was good to read the testimony of a professor who wrote on his Christmas card to his Panel Executive that *"AGARD is the most important source for the knowledge which is incorporated in my lectures"*. Another professor who participated in projects of the AGARD Support to Nations Programme wrote: "*.....I owe every single achievement to AGARD's Support Programme, through which I managed to establish productive cooperative schemes with other European institutes....*". During the review of this AGARD Programme in December 1988 I was fortunate to witness some of the results. Yes, that is also part of AGARD!

Jan A vd Bliek

Jan A. van der Bliek

THE STATE OF THE ALLIANCE AND DEFENSE COOPERATION

Ambassador Alton G.Keel

The Fall 1988 Address to the National Delegates' Board was given by Ambassador Keel, the United States' Permanent Representative to NATO, and we are very privileged to be able to present it here.

I. 40TH ANNIVERSARY

As we in Brussels, in Washington, in Madrid — and other NATO capitals — prepare to light 40 candles on NATO's birthday cake, I am pleased to share some thoughts with you on the eve of that anniversary. When the North Atlantic Treaty was signed in 1949, there was little light in Europe. Economies were still ravaged by the war, and governments were threatened by an increasingly bellicose Soviet Union.

Today, I am pleased to report that the Alliance will enter its 40th year in better health than any of its founders could have imagined; in fact — I would contend — in better health than at any point in its 40 year history.

II. NATO'S ACCOMPLISHMENTS

Why am I so confident? And just what has the Alliance done to warrant *your* confidence — and that of the public? First, we've preserved peace for 40 years — no mean task, when one looks back to events over the past 40 years, or to the two world wars in the previous 30 or so years before that. Second, the world's two super powers just ratified the first treaty in history to *reduce* nuclear weapons, actually to eliminate an entire class of nuclear systems: the INF Treaty ... a true Alliance success story. We took a political decision in 1979 and challenged the Soviet Union to stop deployment of its SS-20 missiles. When the Russians continued, we took an even more courageous decision to proceed with plans to deploy cruise and Pershing missiles in five NATO countries. The peace movement took to the streets in opposition, not understanding that the headquarters of the real peace movement was in Brussels where European leaders had taken that courageous decision. President Reagan proposed the zero option in 1981 — and we spent six long years waiting for the Soviets to realize we meant it. We got the agreement we wanted... through strength, through perseverence, and through unity. In the last two years in particular, there was an unprecedented number of high-level consultations at NATO headquarters. As a result, there was steadfast support by all Allied leaders of the US negotiating position: an extraordinary exhibition of Allied cohesion and solidarity.

III. WHAT'S NEXT?

As significant as the INF Treaty is, it is only the beginning. START negotiations are continuing in Geneva — and, if and when successful, half of the world's strategic nuclear warheads will be eliminated... unthinkable just a few years ago. Can anyone doubt the critical importance of these discussions? And can anyone doubt what our position vis-à-vis the Soviet Union would be today if NATO had *not* shown the political resolve and military strength that gave meaning to our words? It's the lesson of the INF succcess.

However, nuclear weapons, I quickly remind you, are not the only weapons we wish to reduce. Conventional weapons are no less deadly or threatening. The Warsaw Pact has a large numerical advantage in tanks and artillery — in those very weapons capable of seizing, and holding, territory... capable of invasion.

This brings me to my third reason for confidence in this Alliance and its future: the recent NATO summit. You will recall the NATO heads of state and government met in Brussels last March to celebrate the accomplishments of the Alliance, to reaffirm the basic principles underlying your Alliance, and to look at the way ahead. During their meeting, they issued a document challenging the Soviet Union to negotiate a more stable peace in Europe. Yes, in it, NATO called for the "elimination of disparities", including the "establishment of equal ceilings" on conventional weapons. But, just as important, the Alliance called attention to the basic cause of tension — of instability: the unnatural division between East and West. Conventional stability was identified as the core security problem for Europeans and Americans.

We have now been at the negotiating table in Vienna with the Warsaw Pact for more than a year attempting to establish the mandate for these talks. And, if Soviet intentions even come close to Soviet rhetoric within the near future — perhaps before the end of the year — we may be negotiating measures to increase conventional stability.

IV. ECONOMIC CONSIDERATIONS

With this report of past success, and with my expectations for the future, you may wonder if I haven't painted a picture that is a bit too rosy. In fact, there are parts of the picture of the future that should be painted in shades of grey. Let me add some grey. Resources are stretched too thin. Not all Allies are meeting existing commitments. Moreover, there's ample evidence that the burden isn't equally shared among members of the Alliance. Simply put; that

won't do. For comparable benefit, we must assume comparable risks, roles, and responsibilities... even in the face of fiscal constraints.

Unless NATO maintains its strength, there will be no concessions at the negotiating table by the Warsaw Pact. Paul Kennedy, the author of "The Rise and Fall of the Great Powers", as you may know, has cautioned us that we cannot enjoy security without economic prosperity. That argument is self-evident. But so is the converse: We can hardly seek continued economic prosperity while putting our security at risk. Let us not — flush with success — risk reducing our commitment just at the moment when we see such promise in the future. Let us not abandon what works.

How then do we maintain our strength? In part, we must achieve a better return on national investment in order to ensure our security. Many have written in recent years on the need to exploit our technological superiority over the Warsaw Pact. This is easier said than done in these days of rising research, development and acquisition costs, shrinking defense budgets, attempts on both sides of the Atlantic to protect the domestic defense industrial base, and pressure to restrict the flow of sensitive technologies.

Nevertheless, we *must* be more effective and efficient than ever before in our use of resources, and this means we *must not* tire of seeking new and better ways to assure the strength of the Alliance through defense cooperation... in the broadest sense.

V. BURDENSHARING

Before elaborating, let me put all this in context by discussing the major challenge facing the Alliance today from the standpoint of managing transatlantic relations. It's an issue which current fiscal constraints have helped place high on the NATO agenda — the "B" word: Burdensharing.

Since the beginning of the Alliance, member countries have readily agreed that we must all share in the risks, roles and responsibilities associated with the defense of the NATO region. Despite widespread support for this basic principle, differences have inevitably arisen from time to time over whether every nation is in fact carrying its fair share of the collective defense burden. The ensuing debates have typically been very political — since they deal with the allocation of national resources — as well as highly emotional — since they often imply some judgment about the reliability of this or that ally.

The task of measuring any one nation's contributions to the Alliance does not lend itself to any easy solutions. The difficulties in doing so are essentially twofold.

First, the member nations differ considerably in terms of their relative size, economic ability, military capabilities, and security commitments to the NATO area. Thus, what may be a reasonable task for one nation to take on may be less appropriate for another.

A second problem in assessing national contributions stems from the fact that there are no universally accepted criteria for measuring such contributions. A variety of quantitative and qualitative measures have been proffered as reasonable measures of efforts on behalf of the common defense — none of which command universal support. Thus, on the one hand, some might argue that defense expenditures (either in real terms, or as a percentage of Gross Domestic Product) ought to be the principal gauge of a nation's efforts. Others might argue with equal fervor that certain intangible factors (such as maintaining conscription in peacetime or providing facilities and support) should also weigh heavily in the assessment. There are no doubt elements of truth to both approaches.

In any event, there is at present no definitive means of determining whether the burdens of the Alliance are in fact equitably distributed. As a result, the burdensharing issue remains a perennial source of irritation among the Allies as charges and countercharges about level of effort are traded in national legislative bodies, the press, and other public fora. But the Alliance is acting responsibly. It has made "Burdensharing" an *Alliance* issue. In response to guidance from the Defense Ministers at their most recent ministerial meeting last May, the Alliance is currently conducting a thorough review of the entire issue. The assessment is due to be provided to Defense Ministers at the December meeting.

Let me offer a few general comments about burdensharing from the American perspective.

First, we believe that our Allies — as a group — make very substantial contributions to our collective security — often in ways and to an extent little understood or recognised in the American political arena.

At the same time, the record across the Alliance as a whole is very uneven. Some nations have done a first-rate job in maintaining their contributions to the Alliance, despite (in some cases) strong domestic political and economic pressures to do otherwise. Regrettably, this assessment does not hold true in every case. Regardless of how one manipulates the data or accounts for all the intangibles, it is painfully obvious that some Allies have repeatedly fallen short in meeting commonly agreed objectives.

Finally, whatever we conclude are fair measures of burdensharing, the maintenance of a strong and effective Alliance will — in the end — always require of its members a *commitment* to provide sufficient resources to match the existing security *threat*. Whatever winds of change may (or may not) be blowing from Moscow these days, deterrence in Europe for the foreseeable future will continue to require ready and sustainable forces in being. Given the increasing sophistication of modern weapon systems, these forces will almost certainly require an *increase* in the resources devoted to defense. Building public support for such increases will be difficult enough in the light of the attention currently focused on various arms control proposals — and the

fascination with the changes going on and the new mood in Moscow. It will be even more difficult if some Allies are seen to be opting out of their responsibilities, and thereby shifting the burden of collective defense to fewer and fewer shoulders.

VI. DEFENSE COOPERATION

In any eventuality, I accept the fact that to *increase* defense resources will be very difficult — this is already all too apparent in the US. Thus, the United States and the other member states of the Alliance have sought to place even more emphasis on better use of resources through continued emphasis on defense cooperation.

What do we mean by defense cooperation? For the alliance, three of the more obvious areas of cooperation are cooperation in operations, cooperation in logistics, and cooperation in research, development and acquisition of armaments. With the first two I believe the Alliance can be regarded as having good to excellent grades.

VII. OPERATIONAL COOPERATION

In fact, most inside observers say operational cooperation has never been better. NATO's deterrent posture is built on a foundation of operational cooperation, both actual and pledged. This is demonstrated by the commitment to the integrated military command structure in wartime and by the Alliance's extensive exercise program in peacetime. Of great operational as well as symbolic value are the multinational NATO forces we have constituted since 1960: SACEUR's ACE Mobile Force and Naval On-Call Force Mediterranean, SACLANT's Standing Naval Force Atlantic and CINCHAN's Standing Naval Force Channel. While these forces are intended primarily to demonstrate Alliance solidarity rapidly in time of crisis and tension, they have also proven excellent training tools to work out Allied procedures in command and control, communications, surveillance, and battle tactics.

One of our early cooperative *acquisition* successes, the NATO Airborne Early Warning and Control Force of AWACS, of NATO-controlled E-3A aircraft is also now a most remarkable illustration of Alliance *operational* cooperation. This force of aircraft is manned by multinational aircrews, and supports all three major NATO Commanders.

Finally, the potential of operational cooperation between NATO allies has nowhere been better demonstrated, however, than in the recent operation of six allies in the Person Gulf and North Arabian Sea; operations not under NATO's aegis and not within the North Atlantic Treaty area... but an *Allied* success story none the l. .s.

Here, the navies of the United States, France, Britain, Italy, the Netherlands, and Belgium have been providing vital escort, minesweeping, and other tasks in the midst of a bloody shooting war. Yes, it's been done without any integrating command structure or formally coordinated political guidance. But, nevertheless, success is due in no small part to the enormous and unprecedented peacetime development and implementation by NATO forces of standardized operating, logistic, and administrative procedures.

VIII. LOGISTICAL COOPERATION

Similarly, NATO logistical cooperation has realized significant success. NATO's common funded infrastructure program, now 40 years old, remains highly successful and *the* most visible example of Alliance burdensharing. In 1984 the Alliance nations agreed to increase the buying power of the program by sixty percent in real terms — a level which has been maintained since then. Today more than $2 billion of common NATO infrastructure funds are spent annually for such diverse projects as communications satellites, air defense systems, electronic warfare training aircraft, underwater detection systems, and — based on a recent Alliance decision — the facilities to support the transfer of the 401st TFW from Torrejon to Italy. In many respects the infrastructure program is a model for increased Alliance cooperation in other areas.

On the other hand. our grades for mobilization capability are less spectacular. We are concerned about our ability to supply and resupply the greatly expanded forces that we would have in the field in a major crisis and the simultaneous obligation to meet the needs of our populations. At the root of this concern is the realization that effective logistical cooperation is as much a political problem as it is an economic o military problem.

IX. RESEARCH, DEVELOPMENT AND ACQUISITION COOPERATION

Our third example of defense cooperation — research, development and acquisition cooperation — is without doubt the most challenging.

Much effort has been devoted in the recent past to enhance cooperation in research, development and acquisition. Yet I cannot help but feel defense cooperation in armaments is at a critical juncture. We have had a fast start with inventive initiatives, but appear to be getting bogged down by some of the predictable problems: costly programs, tight budgets and an inclination to protect national industrial and technological bases. Throw in nationalism, tactical doctrinal differences and defense organization differences and you can understand why cooperative programs are difficult to get under way *and* to sustain.

True, since the Fall '84 Ministerial Meetings in Brussels, the Alliance has come a long way toward enhancing defense cooperation, primarily through pressure brought to bear at the highest levels of government. We agreed on a conceptual military framework to focus military requirements. We agreed on conventional defense improvements. And we have most recently agreed on a Conventional

Armaments Planning System (CAPS) at Ministerial level. This latest step is extremely important from a political and procedural view. National long range armaments plans will now — for the first time — be offered for review by Alliance nations to facilitate collaboration aimed at meeting NATO force goals. Perhaps, more importantly, CAPS will highlight areas in which NATO force goals are *not* being reflected in national armaments goals.

So, we have today high government-level attention to defense industrial cooperation. Numerous cooperative programs exist throughout the Alliance, with and without the US as a partner. There are eleven programs in NATO using funds made available by US cooperative legislation — the Nunn and Quayle Amendments — eight of which have signed Memoranda of Understanding. There are several more benefitting from Nunn funding in bilateral agreements between the US and its NATO allies.

Yet we still have some nagging problems and concerns — impediments to efficient defense cooperation.

Doctrinal differences are an impediment. Differences in international and intranational doctrinal approaches must be minimized where feasible. This can be accomplished through a harmonization of requirements and the communication of these harmonized reqirements to national acquisition managers for collaboration. The CAPS, with persistent, high-level impetus, should go a long way toward achieving this goal.

Protectionism is an impediment. Economically, governments within the Alliance must effectively convince their legislatures that protectionism does not solve deficit, industrial base, *or* employment problems.

Protectionist measures are a major impediment to trade — much more to cooperation. It is an expensive policy choice. It seeks to protect domestic industry, which in many cases is not competitive or whose products are obsolete, and ultimately results in inefficient resource allocation.

"Buy American" requirements invite retaliation. Ironically, they threaten the traditional US advantage in military trade with the Allies. They serve to spawn European arms cooperation on a similarly exclusive basis.

Similarly, subsidized European industry is no less provocative to Americans — not to mention, anti-competitive as well.

Technology transfer is an impediment — perhaps the most threatening impediment to the future of armaments cooperation. Technology management must be improved. This includes better policy coordination on technology sharing coupled with better controls for technology protection. Lessons learned from the Toshiba/Kongsberg case indicate safeguards must be improved. However, shared modern technology is indispensible to the security of the West. Sophisticated technologies come with high price tags. Now, more than ever, the Alliance must use its existing resources more efficiently. This places a premium on sharing. Greater exchange of information and technology will be critical in the effort to develop a coordinated Alliance R&D program. Most importantly, *co-development* of advanced weapons is the way of the future ... not simply co-production; and certainly not "buy American" or "buy European".

Nationalism is an impediment. Nationalism has historically presented a barrier to arms cooperation. Each nation, if possible wants its own tank and its own aircraft. It goes without saying that each wants its own army, navy, and air force... for understandable, rational reasons. Eventually nations must come to the realization that specialization is worth another look. The Alliance is not ready for specialization of armed forces, but we can do a better job of sub-specialization; that is, in functional areas (such as logistical support) and in roles and missions.

The overall problem of improving defense cooperation is best served then by a diligent effort to identify and impact on these key impediments, while realistically narrowing our focus to areas where breakthroughs are possible. Practically, that tells us to look for ways to rationalize requirements through better armaments planning and to define and exploit opportunities at the component/sub-component level. Certainly, this is where we think some short-term success may be possible as we work towards the larger challenge.

We must be pragmatic enough to identify workable cooperative ventures that pay-off in the near-term, and visionary enough to set our sights higher for the long term.

X. CONCLUSION

May I conclude with a personal note. I would be surprised if you didn't share some of my frustration with the pace of change at NATO. But I would be disappointed if you didn't sense my pride at the direction of change. The shared values of the Alliance remain unshakeable. This Alliance is hardly a 40-year-old artifact of the cold war. It is, instead, the dynamic manifestation of our shared past... and our aspirations for the future.

Yes, we have challenges ahead... just as we've had challenges in the past. We've always risen to the challenge in the past. I am even more confident that we will do so in the future.

ALTON G.KEEL, Jr was sworn in on 13 March 1987 as the United States Permanent Representative to the North Atlantic Council with the rank of Ambassador. Prior to assuming his duties at NATO Headquarters he served as acting Assistant for the National Security Affairs to President Reagan.

Alton Keel was born in Newport News, Virginia, and received a Bachelor of Aerospace Engineering Degree and a Doctorate of Philosophy in Engineering Physics from the University of Virginia. He then attended the University of California at Berkeley as a recipient of a National Research Council post-doctoral award.

Dr Keel began his professional career at the Naval Surface Weapons Center, White Oak Laboratory, Maryland in 1971, and from 1978 to 1981 served on the professional staff of the Senate Armed Services Committee. He was then appointed Assistant Secretary of the Air Force for Research, Development and Logistics, in which role he chaired the Air Force Systems Acquisition Review Council (AFSARC), and the F-16 multinational Steering Committee for the European participating governments. He was also US National Delegate to AGARD.

In 1982, Ambassador Keel was named Associate Director for National Security and International Affairs in the Executive Office of the President, Office of Management and Budget. He was appointed Executive Director of the Presidential Commission on the Space Shuttle Challenger accident in 1986.

Ambassador Keel, whose work has been recognised by a number of awards, is married and has a daughter.

The Panel Chairmen, Deputies and Executives, with their Host, General Bautista Aranda, at the end of the Panel Chairmen's Meeting in Madrid.

NATIONAL DELEGATES BOARD MEETING

Welcome by His Excellency, Rafael De La Cruz, the Spanish Secretary of State for Defence

The National Delegates were welcomed to Spain by the Secretary of State with the following words:

Mr Chairman, National Delegates, Ladies and Gentlemen,

It is an honour and a pleasant task for me to welcome on behalf of the Spanish Government all participants in this annual meeting of the AGARD National Delegates Board. We hope that this meeting will be fruitful and that everybody will enjoy the days they spend in Spain.

Although Spain's participation in AGARD is relatively recent, we have been able to verify the valuable framework for international cooperation which this organization offers. Two symposia, one on Structures and Materials and another pertaining to the Panel for Aerospace Medicine, have already been held in Madrid during the last two years, and now we have the great satisfaction that this meeting of the National Delegates Board is taking place in Spain for the first time.

Spain has a long aeronautical history which began in the first years of aviation, backed up by significant achievements at industrial and technical levels. Over the years this has involved many aeronautical engineers from educational centres, research centres, industry and the Air Force, who have contributed to keeping aerospace activities alive. But today, given the technological advances, it is not enough to work just within one's own country, it is necessary to open up to the outside world to search for collaboration so as to have access to the very latest developments.

If it is necessary to have an adequate industrial base in order to participate in major international programmes, there is no doubt that Spain has this, which makes this participation in cooperative programmes such as the European Fighter Aircraft, transport aircraft, helicopters and satellites, both possible and desirable.

And within this context, it is natural that we look with the utmost interest at the possibilities for international cooperation in the aerospace field offered by AGARD. Spain had contacts with AGARD in the early years of its creation, around the 1950s, taking advantage of the excellent personal relations which its first Chairman, the unforgettable Professor von Kármán, maintained with several scientists of the National Institute for Aeronautical Techniques (INTA). However, Spain's formal participation in AGARD started in 1983, after we joined NATO, and it began to develop in 1986.

Apart from the above, although undoubtedly related to it, there is another reason to justify our interest in AGARD. The present Government is giving priority to the advancement of scientific research and technological development in Spain. It is an essential activity in any nation anxious to progress and not to lag behind more developed countries. The Spanish Government is making great efforts to improve this situation. Certainly, we cannot look forward to dramatic changes overnight. The outcome of ongoing attempts will be perceived only little by little. A very important step in this connection was the approval by Congress in 1986 of the commonly called "Law of Science" which aims mainly at promoting and coordinating scientific and technical research. Simultaneously, in the State annual budget, larger and larger amounts of funds are allocated so that the advancement of research may become a reality. In this sense the Ministry of Defence contribution to Research and Development will reach a figure of the order of 4% of the 1989 budget, which is in line with current practice in other western countries and which was unthinkable only five years ago. However, despite the Government's earnest intentions, there is a fact that cannot be ignored and which limits the pace of advancement: the number of researchers available and the long time required to train good ones.

With that fact in mind, Spain's participation in AGARD is especially attractive. The high-level research and technological development carried out by AGARD in the aerospace field is very intense. Moreover, its operating procedures, with its Panels, its frequent symposia, its excellent technical publications and the large number of participating experts provided by member countries, make it particularly suitable for Spanish scientists and technicians to cooperate more closely with their counterparts in other AGARD member countries.

In a few words, I am in a position to tell you that we look on your activities with the utmost interest and that what we are looking for is an increase in Spanish participation in AGARD.

Finally, I would like to thank you for your presence here in Madrid, to wish you a successful convention and a happy stay with us, which might be well remembered later by all of you, ladies and gentlemen.

Thank you very much.

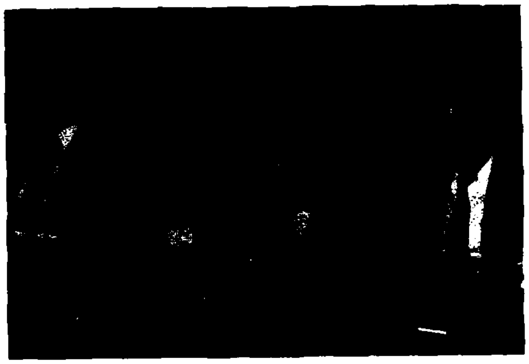
◀The Chairman and Director, attending their first NDB Meeting in those capacities, had the unusual luxury of a whole table to themselves.

Lt Commander E.J.H.Bleeker was among those presented with an AGARD Certificate.
▼

Three professors in the front row: Professor Saada from the University of Paris (North), Professor Jordan, former Chairman of the Board of Directors of DFVLR, who holds a Chair at the University of Bochum, and Professor Madelung, former Chairman of AGARD and a member of the Supervisory Board of MBB, who holds a Chair at the Technical University of Munich. Sitting behind are Major Moustafa Mouhamad, GCP Executive, who was attending his first meeting, his Chairman, Pieter van den Broek, who presented the GCP paper which appears in this issue of 'Highlights', and Mr F.Günther, National Coordinator for Germany.
▼

◀ From left to right in the front row are Major General A.Rossetti, National Delegate from Italy, Professor O.H.Gerlach, National Delegate from the Netherlands, and Dr B.M.Spee, who has succeeded Mr van der Bliek as Director of NLR and as a Dutch National Delegate. In the row behind are Lt Col F.Marchese, Acting National Coordinator for Italy, attending his first meeting, and Lt Commander E.J.H.Bleeker, National Coordinator for the Netherlands, who was attending his last.

A NATO threesome: from left to right are Dr P.J.Berenson, Scientific Adviser to SACEUR, Professor J.Ducuing, Assistant Secretary General, Scientific and Environmental Affairs, and Mr L.Vandendriessche, Financial Controller of NATO. ▶



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Engrossed in their papers are Mr Frank Armstrong, Deputy Director of the Royal Aerospace Establishment at Farnborough and Mr Dale Myers, Deputy Administrator of NASA, National Delegates from the United Kingdom and the USA, and Dr Al Flax, President Emeritus of the Institute of Defense Analyses and Honorary Vice Chairman of AGARD. On the left of Dr Flax is Major General A.J.Melo Correia of Portugal, Assistant Director of the International Military Staff of NATO. Behind Mr Armstrong is the UK Acting National Coordinator, Mrs Diana Halliday, while behind Mr Myers are the US National Coordinator, Major Lee Burge and the NASA Coordinator, Mr Connie Forsythe. In the back row are Colonel Russ Morrison, AGARD's Liaison Officer at NATO HQ, and the outgoing Chairman of the Aerospace Medical Panel, Major General Knud Jessen.

TRENDS IN GUIDANCE AND CONTROL

P.Ph. van den Broek

This presentation was made by Ir. van den Broek to the National Delegates Board Meeting in Madrid in September 1988, on behalf of the Guidance and Control Panel of which he was Chairman, as part of the continuing programme whereby each Panel in turn presents a review of some of its activities to the National Delegates Board.

INTRODUCTION

In this presentation an overview will be given of the trends in the field of Guidance and Control as viewed by the Guidance and Control Panel. First, a review will be given of the areas of interest to the Panel and its activities in the past. Next some changes and developments that are currently going on will be dealt with and their effects on the policy of the Panel will be discussed. Finally, a projection of the trends in the Panel's activities in the near future will be given.

THE FIELD OF INTEREST OF THE GUIDANCE AND CONTROL PANEL (GCP)

Generally speaking, the part of science, research and technology that is covered by the GCP may be characterised as related to:

> "The problem of guiding an object to its destination, taking into account both fixed and fuzzy boundary conditions."

A few key words in this characterisation will be specified.

The *object* may be an aircraft, manned or unmanned, a missile or a guided piece of munition.

The *destination* depends to some extent on the object. For an aircraft, the destination may be the airfield, a simple landing strip, or the target area; for a guided missile or a piece of guided munition, it will usually be the target.

The *boundary conditions* may be of various types. One is the present or initial position of the aircraft or the missile, which may be known or may have to be determined, or the base or launching site from which the mission is to be performed. Other boundary conditions may be terrain conditions and obstacles, which in many cases are fixed, or adverse meteorological conditions, unfriendly aircraft, enemy threats, etc. which in many cases are not known in advance.

To illustrate this characterisation of the general problem a few examples will be given.

1) Landing an aircraft in low visibility on a poorly equipped airstrip

The guidance problem is a to guide the aircraft along a safe approach path to the landing strip. The object is clearly the aircraft, and the destination is the strip. The boundary conditions are easily defined. They are the ground and possible obstacles in the neighbourhood of the strip. The solution to the guidance problem is to determine continuously the aircraft's position relative to the strip and to generate a control to steer it along a safe path. The problem is complicated by the adverse weather conditions, which may prevent direct visual position determination, and the poorness of the equipment on the strip, which may prohibit the use of sophisticated landing aids. The safe approach path need not be limited to the final approach just before the actual landing, but it may also comprise the preceding parts of the flight path.

Fig.1 Landing on a poorly equipped airstrip

Fig.2 Manned attack against a fixed target

2) Manned attack mission against a fixed target

In this case the initial position and the final destination are well defined. The first part of the guidance problem is to define a route as safe as possible, in view of a number of well-defined or ill-defined conditions. The terrain to be overflown will be well known in advance. However, there will be threats that have to be avoided as far as possible. If the threats are known in advance, a flight path has to be selected, which should be a balanced compromise between the concealing opportunities offered by the terrain and the risk of collision with the same terrain. The second part of the problem is to actually guide the aircraft along the selected trajectory, which includes continuous position determination. A very complex problem arises if unexpected threats are encountered. In principle, the whole procedure should be repeated resulting in an adapted flight trajectory but usually the time needed for the evaluations will not be available.

3) Guided weapon release and guidance to a moving target

In this case the object, which is the guided weapon, is to be released at an initial release point and subsequently guided to the target. In this mission a variety of subproblems may be distinguished. At first the target has to be detected and identified. Then it may be necessary to select an appropriate launching position and attitude of the launching aircraft. Finally, after launch, the weapon has to be guided actively to the target, as the latter may be moving at a variable speed. All these actions have to be performed in a hostile environment, so the problems are aggravated by enemy threats.

These examples are intended to illustrate the field of interest of the Guidance and Control Panel. Of course, many more examples could be given. An example of a more complex problem is the guidance of more than one object, which may be the case in air

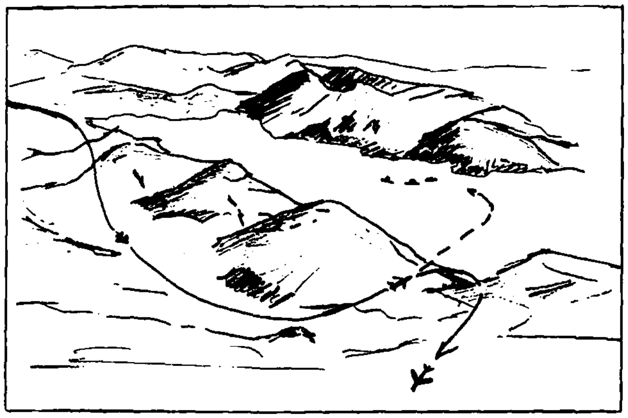


Fig.3 Guided missile attack on a moving target

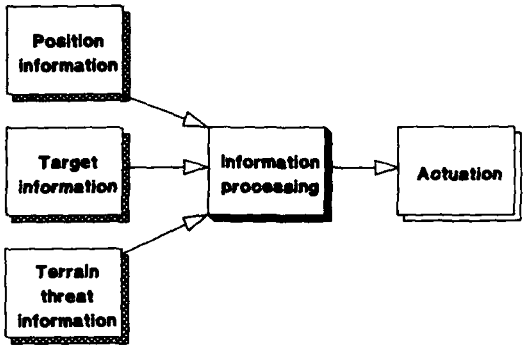


Fig.4 Sub-areas of guidance and control

traffic control or multiple weapon deliveries. However, such examples will not be discussed here.

In the given examples a few common parts can be distinguished. Some of these are:

- Determination of the (present) position of the object. This comprises the area of positioning systems, navigation systems and landing aids.
- Determination of the destination. This is the area of target location, target identification, targeting and sometimes target illumination.
- Terrain, obstacle and threat avoidance, which comprises passive and active radiation sensors, such as Low Light Level Television (LLLTV) and Infrared (IR) sensors, radar and ECM.
- The active control of the object. This covers the generation of control forces, such that the aircraft or the missile follows the requested trajectory. This is not restricted to the typical actuators themselves, such as control surface deflections and thrust vector control, but it includes also the electrical, mechanical or hydraulic systems connected to them.

These sub-areas are part of the larger field of Guidance and Control, and therefore the Panel is interested in details of each one of these sub-areas. In many symposia, sessions are devoted to different types of sensors and actuators. However, this interest is limited. The Panel prefers to view these sub-areas as part of the larger technology area, and is mainly interested in the interconnections. The information provided by positioning equipment, targeting equipment and terrain sensors is used as input to an information processing system, which ultimately provides an output to the control force generating equipment. The result of the entire process should be that the aircraft or the missile accomplishes its mission.

In conventional manned aircraft or, more generally, a human operated weapon system, this information processing is performed in essence by human beings. In many cases, e.g. a single seat airplane, it is performed by one single pilot. One very important area of interest of the Panel is to enable this pilot to concentrate on those tasks that only can be done by a human being. Thus much attention of the Panel has been paid to preprocessing and presentation of sensor information. Also the augmentation of the controllability of the aircraft, including artificial stabilisation, is an important topic. In the guidance of a guided missile it is not possible to include a human controller in the guidance process. Even then a human operator is required, but only for the preparation of the mission. This will include positioning the missile in an appropriate initial condition and preprogramming the guidance system. After launch the guidance is performed completely automatically. Consequently, completely automatic guidance and control systems in various forms belong to the field of interest of the Panel.

From this discussion it may be clear that Guidance and Control is strongly related to other fields of science and technology. The hardware in the sensor which provide the information, and the controller which processes it, are mainly electronic devices. The generation of the control torques and forces to change the velocity vector of the vehicle is a flight mechanical process. And finally, the behaviour of the human pilot as a controller belongs to the field of aerospace medicine. Therefore the Guidance and Control Panel maintains a close cooperation with the Avionics Panel, the Flight Mechanics Panel and the Aerospace Medical Panel.

PREVIOUS GUIDANCE AND CONTROL PANEL MEETINGS

Before entering into a discussion of the projected activities of the Guidance and Control Panel in the near future, it may be useful to review its activities in the past. To avoid too many details, the Panel's activities in the past will be sketched by considering the technical meetings only. These will be taken together in three groups, each one comprising a number of classes. The first group consists of three classes that are related to the pilot of an aircraft. These are:

1) the man-machine interface

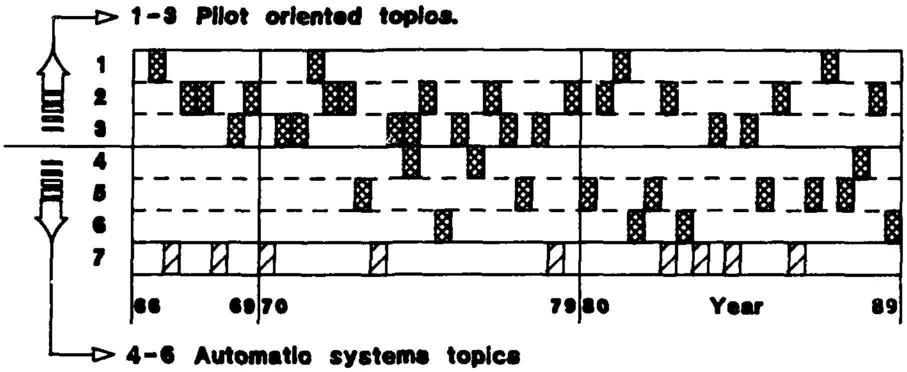


Fig.5 Distribution of technical meetings in time

2) aiding the pilot in navigating his aircraft in a relatively large airspace

3) assisting the pilot in performing aircraft control in a smaller space, such as low level flight and terminal guidance.

The second group is directed to automatic systems that are supposed to perform without close control by a human operator. This group is subdivided into:

4) unmanned vehicles, including remotely piloted vehicles

5) weapon delivery systems, including guided munitions

6) integrated systems

The third and last group consists of one class:

7) Miscellaneous, which comprises meetings on those topics that are difficult to include in one of the other classes, such as optimal control theory, advanced systems concepts, reliability and cost effectiveness.

Figure 5 shows the distribution of these meetings in the time period from 1966 until 1989. It must be admitted that this figure does not really give a clear indication of the trends in the Panel's activities, but some useful indication may nevertheless be deduced from it.

At fairly regular intervals, the Panel has devoted technical meetings to pilot-oriented topics. Most of these meetings were organized around a theme related to sub-systems proposed or developed to assist the pilot in accomplishing his mission task. In these missions the pilot plays a central role in the performance of the total system. He receives information from the sensor systems, processes it using his judgement, takes the necessary decisions, and controls the aircraft. The assistance of the subsystems consists of preprocessing the sensor information and presenting it in a convenient way to the pilot. Furthermore the control task of the pilot may be relieved by the stability augmentation and control enhancement systems.

Due to the increasing effectiveness of these systems the workload of the pilot stemming from the need to gain awareness of his situation has been reduced over the years. On the other hand, the workload has been increased as a result of the increasing complexity of the mission, due to narrowing the boundary conditions such as higher speeds, lower altitudes, more effective threats and meteorological conditions.

Figure 5 shows also that until the early 1970s no technical meetings were devoted to automatic systems, but in later years a considerable number of meetings were organized on systems, where the role of the human operator is less clear or even totally absent. Due to the increasing performance and reliability of guidance and control systems it became possible to omit the pilot from the guidance system, at least for relatively simple and more or less programmable missions.

In an automatic guidance process the link between the sensor subsystems and the actuator subsystems is a more or less smart controller subsystem. Until now such controllers have been far less adaptive than human controllers. On one hand, this rigidity limits the applicability of automatic guidance and control to relatively simple missions. On the other hand, the absence of human flexibility requires an accurate match between the sensors, controller and actuators. Therefore, the performance of an automatic system depends only partly on the performance of the individual subsystems. The interaction between these components is at least equally important. Therefore all aspects of integration of subsystems to a larger overall system are a key issue in guidance and control.

DEVELOPMENTS IN GUIDANCE SUBSYSTEMS

In the preceding section a shift in emphasis has been observed in the Panel's interest from supporting systems in human-managed flight missions to more automation and completely automatic systems. The question arises as to whether this trend will continue, such that eventually the pilot can be omitted from the system for all missions. If this is the case, one could expect that the main interest of the Guidance and Control Panel would be in automatic and autonomous systems. If the pilot's presence remains critical for at least some types of missions, the Panel will continue to pay attention both to human-controlled and automatic systems. To obtain a projection into the future it is necessary to have a closer look at the driving factors behind this trend. Some factors may have been present for some time and may be expected to reach some final state of development, whereas other factors may have emerged only recently and may be continuing in their development for a considerable time. The latter factors may be expected to set the trend for the near future.

Sensor Developments and Data Processing

One important factor affecting developments in guidance and control is the development of sensors. The most accurate guidance is obtained by closed loop control. In that process the actual state of the vehicle is measured, compared with the required state and a correction is made when there is a deviation. This means that in general the guidance cannot be better than the state measurements. In recent decades some types of sensors have shown a considerable improvement. The performance of the classical rotating mass gyroscope has been increased, such that a high accuracy can be combined with a large measuring range.

A new principle of angular rate measurement has been developed into a very accurate device as the ring laser gyro. Target detection at night and in less than optimal weather conditions has been enabled by the developments in low light level television (LLLTV) sensors and infrared (IR) sensors. Future developments may lead to applications that are not feasible at the present time, and this may lead to new system concepts. For this reason, the Guidance and Control Panel will continue to review the developments in sensor technology and their possible consequences for guidance and control systems.

Another factor that affects the development of guidance systems is the preprocessing of sensor data. This may be illustrated by an example. For the positioning of a vehicle at a long distance from ground based beacons, use may be made of a LORAN system. For positioning, two time differences between the reception of three radio signals are measured. Each difference corresponds to one specific hyperbolic line of position and the intersection of two such lines determines the vehicle's position. Until not long ago, the time differences were measured more or less manually and the position was subsequently determined in a hyperbolic grid on a map. Nowadays, a microprocessor is used to determine the position by processing the automatically acquired time differences, to present the position in geographic coordinates. In this case, the application of computing power is used to reduce the workload on a human operator considerably.

The introduction of the microprocessor in the processing of data from ground based navigation aids, such as LORAN, DECCA and OMEGA, has reduced the workload of the human operator. Examples can be given of other positioning systems which are not feasible at all without a microprocessor. Such systems are inertial navigation systems and systems using signals from satellites, such as the transit and NAVSTAR-GPS systems. The amount of computer power required for these systems exceeds human capabilities by orders of magnitude. These examples show that microprocessor technology enabled the development of new positioning systems that are different by nature from the classical systems. In that way, this new technology initiated a new direction in guidance and control. The Panel will closely follow these developments in the future.

The developments in sensor technology have resulted in a variety of systems to support the pilot in the accomplishment of a mission. For positioning and navigation, use may be made of visual contact with the terrain, radio navigation aids, satellite positioning systems or an inertial navigation system. Target acquisition and identification may be accomplished by visual contact direct or by using LLLTV-sensors or IR-sensors, or by a Radar system. Before weapon release, a targeting system may be used. Each one of these systems may be useful in one or more phases of the mission flight, and the miniaturization and computerization of the systems made it feasible to install a considerable number of these on board an aircraft. This trend has two important consequences, both of which will have the attention of the Guidance and Control Panel.

1) Application of many subsystems will increase the total cost of the aircraft as a weapon system. At this time affordability is often a problem and that is likely to continue. The Panel will continue to pay attention to the topic of cost, cost effectiveness and affordability of systems.

2) The other drawback of many useful subsystems is that the workload associated with the management of those subsystems may very well nullify the reduction obtained by the preprocessing of the data in the individual sensor systems. This results in a trend to combine the separate subsystem into a larger integrated mission management system. This trend has been going on for quite some time, but also in this area the developments are increasing in speed due to the application of computer technology.

Actuators and vehicle control systems

Thus far, attention has been given to the sensor side of the guidance and control problem, which provides the inputs to the pilot or controller system. The output side, being the actuator system and the vehicle control, also deserves some attention. In this area considerable progress has been made as well, and it will continue to do so. New developments in the actuator hardware have resulted in increased bandwidth. Research is being done on digitally-controlled actuators to construct devices which are directly compatible with digital controllers. Theoretical and experimental work is being done on thrust vector control. The result of all this is important for the performance of control systems, and in particular for the guidance and control of guided weapons. The effect on the general trend in guidance and control science is still not quite clear. As a matter of fact, the given examples are related to a component in the forward path in a control loop. This means that a decrease in performance of an actuator is measured by a sensor and can subsequently be compensated for by the controller. Thus, although developments in actuators are important, it is not likely that they will have a large impact on the Guidance and Control Panel's policy.

In particular for pilot-controlled flight the control of the vehicle is improved considerably by increasing the controllability of the vehicle. This is realized by the application of automatic systems, such as dampers and flight control systems. Also in this area considerable progress has been made, but a state of maturity has been reached by now. Therefore it is not likely that future developments will redirect the trend in guidance and control.

Developments in controller design

Finally the development related to the central part of a guidance process, namely the controller, will be discussed. For manned missions, the ultimate controller is the human pilot. Although the Panel pays a lot of attention to subsystems designed to aid the pilot, the Panel does not feel itself qualified to discuss improvements in or changes to this human controller. In many missions the human operator is the central part, managing the different systems in varying circumstances. The Panel is very much interested in the performance of control systems, controlled by a human pilot, but only the effects of changes in the surrounding subsystems are considered and not changes in the pilot himself.

However, for some types of missions an automatic controller could be used. These used to be missions that consisted of a predictable sequence of phases, and for each phase an appropriate guidance and control system might be activated. In many cases such missions consisted of only one phase. This could be a guided weapon that is launched after its sensor has acquired the target. The mission then consists of a homing control to the target. The mission for a medium range cruise missile may consist of a navigation phase to the target, followed by a target-acquistion phase and a homing phase. Characteristic of such missions is that the system has one standard response to each expected type of situation, whereas a pilot may be expected to judge the situation and to respond after weighing sometimes contradictory factors.

A new development in computer technology and software is the area of artificial intelligence. In principle this comprises the generation of software that acts more or less intelligently. This is a large area, in general of interest to information scientists and information process engineers. One part of the area of artificial intelligence is the so called "expert systems". An expert system is a software system that can handle large amounts of knowledge. It can be applied in diagnostics, both in the medical sense and in the technical sense. In the knowledge base of the system a large number of relationships between possible causes and consequences are stored. An operator may feed the system initially with a number of symptoms and the system then searches for possible causes. Based on this, the system may ask for additional information on symptoms and, in the ideal case, the system will end with a unique cause that explains all the symptoms. In practice, it may not be possible to find a unique cause and then the system may end with a number of causes, each one provided with an indication of its likelihood.

Guidance and control functions executed in manually flying an aircraft involve human capabilities which may be skill-based, rule-based or knowledge-based. Classical control theory has enabled us to transfer most of the skill-based and some of the rule-based functions to automatic systems. The indicated new developments in computer and software technology make it possible to design automatic systems for assistance to, or even replacement of human knowledge-based control functions. Such functions may not only be related to air vehicles, but also to mission and battlefield handling.

One can envisage an unmanned aircraft equipped with an expert system. The inputs, comparable with the symptoms mentioned, can be obtained from the different sensor systems on the missile, and the system could continuously assess its situation and react correspondingly. It is admitted that this idea is more a vision or a prophecy, rather than a prediction. In certain areas, expert systems are already in use but in other areas it can be shown that many problems have still to be solved. It is also likely that systems fully controlled by an expert system will not be realized in the near future, and one intermediate step will certainly be that an expert system is used as an intelligent adviser to the human operator, giving advice, with reasoning if required, whereas the human operator maintains ultimate control. In this area of science and technology many unforeseen and hardly predictable developments will be made in the future. It is uncertain how far it will progress in the next decade, but the direction is very clear. The Panel considers it a challenge to keep track of the relevant

developments and to stimulate initiatives to apply such software systems for the improvement of guidance and control systems.

Summary

At the end of this section it may be useful to summarize the developments in the various areas in the field of guidance and control.

The developments in sensor technology and sensor data preprocessing tend to result in a decrease in the pilot's workload as far as situation awareness acquisition is concerned. The same trend is visible in the workload for vehicle control due to the developments in actuator technology and vehicle control. Nevertheless, the total pilot's workload has not decreased over the years, but the emphasis has shifted from aircraft control, including positioning, to management of the aircraft as a weapon carrier in an operational environment.

The Guidance and Control Panel will continue to review the means to assist the pilot in accomplishing his mission. To this end the Panel will not only continue to deal with systems providing the pilot with an optimal awareness of his situation, but also with advisory expert systems providing an assessment of his situation in the battle area.

The developments in controller design and technology are such that an increasing number of missions may be performed by automatic systems. Therefore the Panel will also continue to pay attention to automatic systems. In that sense the trend, indicated in Figure 5, will continue so that human and automatic systems will share the larger part of the Panel's activities more or less equally. Furthermore, it is expected that the most important achievements in both these areas will be due to developments in computer and software technology. As a consequence the emphasis of the Panel's activity is expected to shift from hardware, sensor, positioning and control systems to control software and artificial intelligence.

CONCLUSIONS

In this presentation it has been shown how the Guidance and Control Panel deals with the developments in science and technology in the field particularly of interest to the Panel. The trends in guidance and control have been indicated by the choice of topics for the technical meetings over the last two decades. To explain these trends in order to make a prediction of the trends for the near future, the character of the progress has been examined in some detail. This leads to the conclusion that flight management by the pilot as a human operator will remain critical in many types of mission in the future. Nevertheless, application of automatic guidance and control will increase gradually in other missions. This will lead to a continuation of the distribution of emphasis between human-operated systems and automatic systems. However, it has also been indicated that new developments may be expected from the developments in computer technology and the associated software, in particular in the area of artificial intelligence. These developments may have a considerable impact on the design and the performance of guidance and control systems. The Panel is very interested in these developments and expects to devote an increasing number of activities to system software. Therefore, a shift in emphasis will be visible in the interest of the Panel, from hardware-oriented topics to software-oriented topics in the near future.

IR. PIETER VAN DEN BROEK received his education in Aeronautical Engineering at the University of Technology in Delft, The Netherlands. He received the degree of Aeronautical Engineer in 1964. In that year he joined the Department of Aerospace Engineering of Delft University as a scientific assistant. His research activities have been concerned mainly with the application of control theory to aircraft and spacecraft.

In 1970 Mr van den Broek became an Associate Professor in stability and control of aerospace vehicles at Delft University. In 1971 he was appointed as a part time Professor in Flight Mechanics at the Royal Military Academy in Breda, The Netherlands.

Mr van den Broek became a member of the AGARD Guidance and Control Panel in 1973, was elected Deputy Chairman in Spring 1986 and Chairman in 1988.

He is married and has three children.

SPANISH NATIONAL DAY
1988

The Spanish National Day — Thursday 22nd September — started with technical presentations given by senior members of four leading Spanish aerospace or defence organisations. They were followed by visits to three such organisations. The texts of the presentations are given below, as are brief notes on the technical visits.

The day finished with a banquet hosted by the Secretary of State for Defence, Señor Don Rafael de la Cruz Corcoll, at the end of which he summarised the aim of the day's events, as follows:

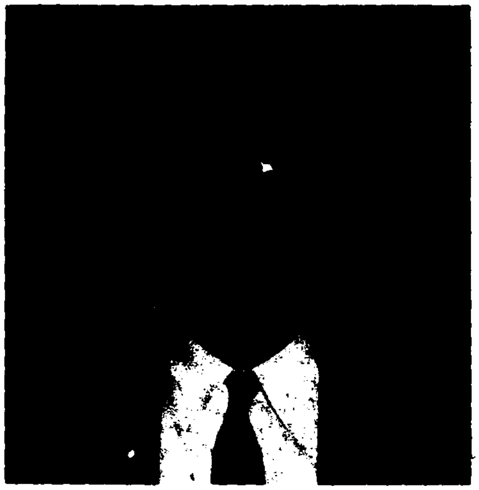
Mr Chairman, National Delegates, Spanish guests, Ladies and Gentlemen:

Allow me to hold your attention for a moment.

Throughout this day we have tried to offer you a general perspective of our capability in the aerospace field, together with the principal activities which are presently taking place in Spain. First there were technical presentations followed by visits to some of our centres and industries. Evidently, despite our good will, you saw only a part of what we have and what we do in the field of aeronautics and space. Notwithstanding, for experienced professionals as you are, they surely enabled you to get an approximate idea of where we stand and what we are able to do. Let me add something I mentioned to you yesterday morning: that we look forward to increasing our scientific and technical cooperation with AGARD member countries. And a good starting point is certainly to improve our mutual knowledge. For this reason, I am very pleased with the opportunity you gave us today to show you — even though it may have been rather incompletely — our capability and our possibilities in the aerospace field.

On another subject, I do hope that the ladies have had a nice day in Toledo, surrounded by the quaint atmosphere of a historical site which was at one time one of the leading cultural cities of the world.

Let me thank everybody for their presence and I raise my glass in wishing the best to all members of the AGARD family, for its continuous success and for a lasting and close friendship among the individuals and countries participating in it.



RAFAEL DE LA CRUZ Corcoll was born in Barcelona in 1945 and after graduating in Economics from Barcelona Central University he worked for the Government in the 3rd Plan for Social and Economic Development until 1972.

In 1974 he entered the Treasury Department as Inspector, becoming Auditor the following year. He was appointed Subdirector General of Sectorial Planning in 1976 and became a member of the Economy Seminar of the Mediterranean Area in the Centre of the Superior Studies on National Defence in 1977.

In 1980 Mr De La Cruz was selected by the United Nations for its International List of Experts in the field of global and sectorial planning, and in 1982 was awarded a Diploma by the International Monetary Fund. He subsequently returned to the Treasury Department, being appointed Director General of the Budget in 1984.

In 1986 he was appointed Secretary General for Planning and Budget, with the rank of Under-Secretary in the Government and, after completing several assignments with the European Economic Community, was Spanish representative at a Public Budget Seminar held in Washington jointly by the Finance Department and the IMF.

Mr De La Cruz received his present appointment as Secretary of State for Defence in April 1988.

He is the author of several books and newspaper articles on the subject of economy and public revenue and is married with two children.

DEFENCE AEROSPACE RESEARCH AND DEVELOPMENT IN SPAIN

Manuel Quinteiro
Subdirector General of Research and Technology in the Ministry of Defence

The National Armaments Director of Spain was supposed to speak today about Aerospace Research and Development in Spain, but due to other commitments he is unable to attend this meeting and has asked me to substitute for him. I am going to speak about the problems of defence aerospace R&D. In any case I shall keep it short.

Spain is a country which started aeronautical activities very early on. The first plane with an engine was built and registered in Spain as early as 1909. Space activities began in 1961 with the establishment in Spain of a satellite tracking station, within a NASA collaborative programme which continues today.

Since then, the intensity of the activities in these areas has been very variable in line with the evolution of the world industry and the political situation in our country.

In general, Spain gave little attention in the past to research and technological development. We have had great scientists and researchers who have left their mark in major areas of science and technology but who have always acted in an individual way and, in most cases, the country has not benefited from their achievements.

It has only been in recent years that a real effort has been made to organize research and development and, in spite of this, our levels of performance measured against the percentage of our GNP allocated to R&D are already half that of other European countries. As an example of this effort, I can tell you that in the last six years, the budget that the Ministry of Defence allocates to R&D has been multiplied by 20 and is still increasing at a higher rate than the rest of our defence budget.

The requirements that our Armed Forces have as a consequence of modernization, and the recent incorporation of Spain into international organizations such as the EEC, NATO and IEPG, have contributed in a very decisive way to this change of attitude and this opens up the possibility of participating in European projects, working jointly with institutions and industries of other more developed countries.

The National Plan for Scientific Research and Technological Development for the year 1988–1991, which provides public funding for R&D programmes, has available 522,000 million pesetas, which does not include Defence R&D Programmes, which for the same period can be estimated at 260,000 million pesetas. To this figure has to be added the contribution by supranational organizations such as the European Economic Community and the European Space Agency, which can be estimated at 110,000 million, and which in total reach a figure of nearly 900,000 million pesetas in public funds for R&D in Spain in the current quadrennium.

In order to take full advantage of this amount of resources, a significant number of technicians and scientists is required, but this is very difficult to achieve since it coincides with a period of growth in Spanish industrial activity, which brings with it a heavy demand for this same kind of personnel. This problem is even more serious than the lack of resources since it requires a long-term solution. The problem is becoming more acute in the Defence Research and Development Centres as Civil Service salary levels are not in line with those of industry.

Defence Research and Development is under the Sub-Directorate for Technology and Research, SDGTECIN, with DGAM, which reports to the State Secretary for Defence.

The SDGTECIN task is:

- To propose, promote and manage the plans and programmes for research and development related to weapons and equipments of interest to National Defence.

To achieve this, SDGTECIN carries out its activity in R&D through:

- Management of Research Centres and Experimental Areas of Defence.
- Contracts for Research and Development with the Industry and Research Centres.
- Coordination and management of participation in international programmes for R&D.
- Collaboration with other Spanish Research Bodies.

The nine research centres and experimental stations reporting to SDGTECIN are a result of linking some centres into the central organization that, prior to the integration of the Armed Forces into the Ministry of Defence, reported to each one of the different Forces. They are being reorganized, grouping them into technological areas, and coordinating their activities so as to avoid

duplication, and assigning them new activities according to the current needs of the Defence Ministry.

Apart from these research and development centres, within the Ministry of Defence there is an autonomous body, reporting directly to the Secretary of State for Defence, which is the National Institute for Aerospace Techniques, INTA, where most of the Defence research within the aerospace field is done, and about which we are going to give you a detailed presentation as the next item on today's programme.

More than 90% of the resources devoted to R&D for Defence goes to companies in contracts for Research or Development. SDGTECIN devotes a great deal of its time to the setting-up, management and accounting of these contracts, in which we have a high degree of interest.

The Spanish industries which work with Defence are improving considerably. Co-production work and the industrial compensations required in respect of the import of defence material (eg F-18) and participation in European programmes such as ESA and EEC are producing results which allow them to obtain contracts independently abroad, and to participate without difficulty in international Defence programmes, forming consortia with leading companies of the world. It is possible that in the presentations this morning we will hear more about this.

The resources allocated to international programmes in the aeronautical and space field are very much higher than those allocated to national programmes, because of our desire to open up and collaborate in defence matters. Given the nature and methods of operation of this type of international programme, within our country we carry out work of a value more or less equal to our financial contribution. We are most concerned about the technological level of this work since one of our basic objectives is to raise the technological level of the Spanish industry, which will allow it in the future to manufacture products which are more advanced, more competitive and thus more highly valued.

We feel that the proportion of resources spent on international programmes and on our own programmes should be modified in favour of the latter so as to increase the capability of our laboratories and to improve our industry's technological level.

I have dealt with the question of research and development in Defence, with some reference to the aeronautical and space field, in a very superficial way because the Chairman of INTA, the best research and development centre we have in Defence dedicated to aerospace matters, is going to speak next, followed by the Chairmen of two of the most prestigious Spanish industries in this field.

Manuei QUINTEIRO Blanco graduated in Chemistry at the University of Santiago and was later awarded a Master's degree in Nuclear Engineering by Massachusetts Institute of of Technology. Since then he has been a researcher in the Junta de Energía Nuclear (for 15 years) and a Professor in the High Technical School of Mining Engineering (for 5 years).

He was responsible for the foundation of the Institute of Nuclear Studies and Director of Programmes for Nuclear Engineering courses there. He was also one of the founders of the Spanish Nuclear Society and its Security General for four years. He is a member of the Directing Committee of the European Nuclear Society.

Mr Quinteiro has founded two electronics companies and was Chairman of both. He was also Chairman of a consortium of companies set up to build a nuclear reactor. At present he is Subdirector General of Research and Development in the Ministry of Defence.

PRESENTATION OF INTA TO AGARD

Pedro Perez del Notario
Director of Scientific and Technological Cooperation of INTA
(National Institute for Aerospace Techniques)

INTRODUCTION

It is a great privilege for INTA to be introduced to AGARD through its most important body, the National Delegates Board, in its first meeting in Spain.

INTA, as an aeronautical establishment is known to most of you very well known personalities in the aerospace field. On the other hand, INTA has known AGARD since its very beginning in 1951, because Dr von Kármán, the founder of AGARD, maintained a close relation with INTA at that time. INTA would like to express, once more, its gratefulness to the never-forgotten Dr von Kármán. With his guidance, INTA was able to establish relationships with other aeronautical institutions and became a member of international organizations such as the International Union of Theoretical and Applied Mechanics (1950). Furthermore, with his help INTA created a new scientific working team in the field of combustion that is still working in this area today.

In the past, INTA has followed AGARD activities only with some limitations, even though some of its people have taken part in some technical meetings. Therefore, Spain's becoming a member of AGARD means for INTA a great improvement in its possibilities for scientific and technological development.

INTA DEPARTAMENTOS	AGARD PANELS
AVIONICA Y ELECTRONICA	AVIONICS
	ELECTROMAGNETIC WAVE PROPAGATION
AERODINAMICA Y AERONAVEGABILIDAD	FLIGHT MECHANICS
	FLUID DYNAMICS
MOTOPROPULSION Y ENERGIA	PROPULSION AND ENERGETICS
ESTRUCTURAS Y MATERIALES	STRUCTURES AND MATERIALS
SISTEMAS DE ARMAS Y EQUIPO	GUIDANCE AND CONTROL
COMBUSTIBLES Y LUBRICANTES	AEROSPACE MEDICAL
PROGRAMAS ESPACIALES	TECHNICAL INFORMATION

Fig.1

Afer this excursion into the past, I am going to talk about the future, since research and development in the aerospace field is the real future.

The Instituto Nacional de Técnica Aeroespacial (INTA) is an Agency of the Defence Department whose aim is research and development in the aerospace field. It employs about 1400 people and has a budget of US$33 million. It is divided into seven technical departments, each one applied to a specific field. These fields have a great similarity to the different panels of AGARD, as you can see in Figure 1.

R&D ACTIVITIES

The **Department of Avionics and Electronics** has activities in the field of navigation, communications and electronic equipment. We must emphasise the important level reached by this Department in the development of TT&C antennas in S Band, many of the European satellites using them. The main research projects now under development in this area are:

- Studies on TT&C antennas on Q Band.
- Studies on multibeam antenna systems.
- Theoretical and experimental study of the effect of the geometry of a satellite in the radiation pattern of low mean gain antennas.
- Research and Development Techniques for low visibility RADAR.

The **Department of Aerodynamics and Airworthiness** includes the study of aerodynamics, flight mechanics and flight testing. It has two low speed subsonic wind tunnels. In one of them the aerodynamic coefficients of the latest Spanish aircraft C-212, C-101 and CN-235, have been obtained. This department has technical responsibility for the certification of these aircraft.

Among others, I must highlight the following research studies:

- Aerodynamic effect of heavy rain on aircraft performance.
- Studies on non-stationary aerodynamics.
- Studies on transonic aerodynamics.

The **Propulsion and Energy Department** carries out the activities related with power plants, including

engines and their installation in the aircraft. During the last decade we have not had many activities in the area of engines. The Department has test-benches for testing reciprocating engines and turbojet engines under normal environmental conditions.

The present main lines of research and development are:

- Studies on infrared emission of ships.
- Noise control by measurement of acoustic intensity
- Combustion in microgravity.
- Testing of solar photovoltaic cells for space applications.
- Research, study and development of thermal control systems.

The **Department of Structures and Materials** focuses its activity on problems associated with materials for space application and the testing of structural systems. The Department has a great number of materials-testing equipments and structures-testing facilities. The main lines of research are:

- Technological development of composite materials with a metallic fibre reinforcing aluminium matrix.
- Wear behaviour optimization in steel elements with graphite cementation.
- Optimization of the use of composite materials.
- Characterization of composites of organic matrices reinforced with carbon fibre.
- Aeroelasticity.

The **Department of Weapons Systems** caries out activities on solid rocket motors, guidance and in-flight weapon testing. The main facilities are a test bench for solid rocket engines, and simulation facilities for testing guidance and control systems. At El Arenosillo (Huelva), INTA has a launching range for sounding rockets. It also provides trajectography services for missile flights. The activities of this department are closely linked to the Spanish Ministry of Defence.

The **Department of Space Programmes** is a new INTA department devoted to space science, remote sensing and space-station tracking.

The main activities in space science are:

- Ozonospheric programme.
- Cosmic radiation.

The Maspalomas (Canary Islands) tracking station receives images from several satellites, such as: LANDSAT 5, MOS-1, SPOT and others.

Other Activities

Besides activities directly related to aerospace research, INTA also helps Spanish industry and government institutions in fields such as:

- Testing of equipment for industry, for instance fatigue testing of the landing gear of the CN-235 aircraft.
- Environmental and mechanical testing of space equipment.
- Different technical tasks for the certification of Spanish aircraft.
- Technical assistance to the Spanish Ministry of Defence in several programmes.

In the space field, INTA operates the tracking stations at Villafranca del Castillo for ESA and Madrid for NASA. INTA also makes elements of space equipment directly for ESA or through European companies. In international cooperation, we must also highlight our relations with NASA of United States and DFVLR of the Federal Republic of Germany.

Pedro PEREZ DEL NOTARIO y Martínez Marañón graduated as an Aeronautical Engineer in 1957 and was awarded a Doctorate in 1961. Throughout his professional life he has been actively engaged in matters relating to combustion and energetics.

He joined the National Institute for Aerospace Techniques (INTA) in 1957 and was assigned to the Motor and Propulsion Department. He was later appointed Technical and General Secretary of the Institute, where he presently holds the position of Director of Scientific and Technological Coordination. He was appointed Professor of Thermodynamics at the Superior Technical School of Aeronautical Engineers in 1978.

RESEARCH AND DEVELOPMENT IN THE SPANISH AEROSPACE INDUSTRY

Javier Alvarez Vara
President of Construcciones Aeronauticas S.A. (CASA)

INTRODUCTION

The analysis of R&D activities in the Spanish Aerospace Industry has to be done from two different aspects. Although these two aspects should be closely interrelated — and in fact are interrelated in most of the EEC member countries — in Spain they are somewhat disconnected. These two aspects or factors act somehow "pseudo-independently" of each other and therefore the final output of aerospace R&D is jeopardized.

These aspects or factors are:

- INDUSTRIAL R&D FINANCING
- IMPLEMENTATION OF R&D ACTIVITIES

INDUSTRIAL R&D FINANCING

The financing by the Government of R&D activities in the aerospace sector acts in a different way depending on whether the R&D activities are related to:

- Research and Technology (R&T) which include all the activities in research and development of technologies which are not directly related to prototypes and/or products, or
- Technological Development (D) which includes the development of technologies directly linked to the prototypes and to the manufacturing process of a given product.

The Spanish aerospace sector has access to almost all support measures implemented by the Government. However, those measures are taken globally at a national level to foster general activities of R&T. In fact those measures consider Science and Technology in its broad sense although certain priority areas are defined.

The aerospace sector is therefore considered at the same level as other sectors in every scientific area. This, in fact, is a big disadvantage to the aerospace sector since:

a) The normal research cycle to implement a given technology in an aerospace product is very long (from 5 to 10 years).

b) The normal volume of any aerospace project, not only in the resources needed but also in the participating industries/organisations, and sometimes different countries, is very large.

These facts mean that aerospace requires specific support from the Government, particularly when the broad possibilities of application of aerospace technology to other industrial sectors are considered.

We can therefore conclude that the financing of R&T activities in the Spanish aerospace sector is supported almost entirely by the industries themselves, with very few exceptions, such as Airbus. This is a peculiar aspect of the Spanish aerospace industry. Other EEC aerospace industries, with the exception perhaps of Belgium and the Netherlands, are embedded in a more favourable environment as can be seen from Table 1.

In fact, the EUROMART project, not yet launched, represents a tremendous hope. The EUROMART project will allow the Spanish aerospace sector to participate in R&T collaborative programmes within the EEC and represents a unique opportunity to foster the technological evolution of the Spanish industry.

Finally, it has to be said that Government participation/contribution in opportunities of Technological Development/Prototypes is generally dependent upon its international cooperation policy.

TABLE 1

Financing	RESEARCH & TECHNOLOGY		
Country	Government	Industry	Research Inst.
Germany	XXX	XXX	–
Belgium	X	XXX	–
The Netherlands	X	XXX	–
Spain	X	XXX	–
France	XXX	XXX	–
Italy	XX(X)	XXX	–
United Kingdom	XX(X)	XXX	X

IMPLEMENTATION OF R&D ACTIVITIES

The implementation/execution of R&D activities within the aerospace sector also has to be considered differently depending upon whether those activities refer to Research and Technology or to Development.

The global strategies of aerospace R&T are undertaken by, and are under the responsibility of, the aerospace industry. However these strategies interact with national strategies, particularly those related to Defence. For short term objectives/ projects all the effort is carried out by the industry. This effort is based on the present technological level/know-how and, obviously, on the availability in the industry of human and financial resources.

The Aerospace Industry Gives its First Priority in Assigning Financial Resources to this Process (R&T (D) in the Short Term)

The industry also defines the medium term objectives/projects at a global level. However, the Government also establishes corresponding budgets, which, not being specifically set up for the aerospace sector, allow for coordinated action with Research Institutions and Universities. To that end, the Government has set up a "National R&D Plan". This Plan includes programmes and projects on different technological areas. However, there is no specific programme/project particularly devoted to aeronautics. Nevertheless, it will allow the aeronautical industry to participate in programmes/ projects which can have a direct application to its sector, such as materials, software, computerisation, etc. It has to be mentioned that within the "National R&D Plan" there are small efforts to include some space projects, but those affect several industrial sectors.

It can therefore be said that the main human and economic efforts are carried out by the industry.

For long-term programmes, the technological objectives are planned and established as a basis for activities that are, for the most part, undertaken by Research Institutions and Universities. This long-term phase is mainly financed and supported by the Government. However, the level of activity for the long-term programmes is, in Spain, very reduced and therefore its effectiveness, as far as the aerospace industry is concerned, is practically non-existent.

Here again, space and aeronautics receive a different treatment:

- There is a National Space Plan which is more focused on D&T activities than on R&T.
- There is no specific plan for aeronautics.

The industrial strategy for development is shared with Government and somewhat follows the Government guidelines. In the particular case of CONSTRUCCIONES AERONAUTICAS (CASA) — an aerospace systems company, and therefore a high technology company — there are several lines of action:

- Own products.
- Products/programmes in cooperation (national/ international) in which the company and/or the Government consider their participation as a result of their strategic policy.

These strategies/lines of action are not exclusive to CASA and can be extended to other industries, although they are exclusive to the aerospace sector.

Within these global strategies of R&T&D, CASA identifies and structures its R&D programmes as a consequence of a "*Certain Technical and/or Operating Need*" to improve the market share of one or several of its products and/or services. That means that no R&D programme is undertaken unless it has a clear impact on its business plan. Priorities are established, the highest being those that have a direct impact in the short term (as has already been mentioned).

In CASA's present environment, the identification of technical/operating needs means:

- To continue to increase the R&D activities in the area of structures and new materials, such as:
  - High temperature composite materials.
  - Superplastic forming and diffusion bonding.
  - Aluminium-lithium alloys.
  - Protection and stealth materials.
  - Damage and fatigue-resistant structures.
  - Advanced computation methods.
  - Low noise generating/propagating structural solutions.
- To assimilate, develop and use advanced methods and tooling, such as:
  - Increase CIM technologies.
  - Expansion of CAD/CAM technologies to the system/sub-system design level: wiring, piping, avionics.
  - Integral O.R. analysis.
  - Automated and integrated production systems.
  - Advanced inspection systems.
- To implement rapidly integrated methodologies of management and control, as an integrated system of production planning and control (SPRINT).
- To expand our engineering capabilities for the design and development of our own products and/or subsystems since "*the capability of always being at the technological edge is a key factor for a good market penetration*".
- To optimise the present infrastructure, through:
  - CRAY supercomputer.
  - Technology laboratories.

- Test and prototypes laboratories.
- Cooperation and integration of national resources (INTA; Research Institutions; other companies).

— To improve our situation in the establishment of the big Cooperative Programmes, as *"the important factor at the beginning of any development is to have the know-how of the appropriate technology"*, which means:

- The establishment and accomplishment of specific R&T projects (compatible, if possible, with the Government programme in certain areas: materials, space, automation).

— Participation in International System Development Programmes in the following areas:

- System integration.
- Computation, including the methodology, the model and the simulation.
- On-board computers.
- Propulsion.
- Prediction, detection and diagnosis.
- Armament systems.

— To improve our present situation in Aerodynamics and Flight Mechanics by:

- Adequate infrastructure and analytical methods for the study of the complete aircraft.
- Boundary layer active control.
- Appropriate methods for data acquisition and processing via experimentation.

— To develop and improve our flight test capability, via:

- Parameter identification.
- In-flight instrumentation.
- Simulation.

Once the needs have been detected, its implementation, in order for those needs to have a clear impact in CASA's business plan, requires the financial and technological identification of Programmes/Products to which these technologies/methodologies would apply. Those Programmes/Products are:

— CASA's own products: C-101, C-212, CN-235.

— Effective and plural participation in the European Fighter Aircraft (EFA).

— Development of a Tactical Aircraft for the Spanish Air Force (EA-AX).

— Continued and expanded participation in the Airbus Programme (A330/340).

— Participation in Space Programmes (the National Space Programme will allow improvement in our participation in future ESA programmes).

— Definitive, active but also selective, participation in the cooperative programmes: EUROMART, EUREKA, BRITE, ESPRIT, IEPG,...

— The accomplishment (in close coordination with the Administration) of R&D programmes which are contemplated in the National R&D Plan, for selected areas: space, materials, electronics,...

— Participation in the Light Attack Helicopter Programme (LAH).

— Participation in missile programmes: MSOW, Roland.

The identification of the above programmes, for which specific R&D activities are selected, is based on the following concepts:

— CASA, being responsible for the development of a system, does not need a detailed knowledge of all techniques/technologies but must have a capacity for:

- Design at a global level.
- Analysis, conception and specification.
- Developing the technologies/processes/products which affect its specific lines of action.
- Integration, testing and certification.
- Commercialisation of its products together with a strong product support.
- Management and control of system development.

— CASA, not being a diversified company, but being responsible for complex and high technology systems, has to be and is immersed within a wide technological variety.

— CASA, through its own experience and the general experience of the aerospace sector, realises that its own technology (to be incorporated in the medium/long term development programmes) has been obtained through Research and Technology Programmes and Development Programmes applied to prototypes as test benches and/or operating prototypes. CASA also knows by experience that these programmes are generated and developed as cooperative programmes with the exception of those which have very specific constraints and which are generally linked to Defence aspects.

Unfortunately, in very few cases does the Spanish Government support financially the development/utilisation of technology demonstrators (platforms used for experimentation and validation of a given technology).

An example of what has been said is the CN-235 Programme totally financed by CASA at its own risk as opposed to the EFA and AIRBUS programmes, both international cooperative programmes, supported by the Governments of the participating countries as a consequence of their Industrial and Defence policies. In Spain, that means that, with the exception of AIRBUS, only Defence is financing R&D for systems/products.

The above concepts have a direct influence on CASA's strategy. The optimum integration of national resources is required for its R&D projects. Those projects (considering the special technological/industrial circumstances of Spain and its aerospace sector) have a triple influence:

- Ideal R&D driver.
- Industrial booster/spin-off effect.
- Means for the participation of other industries in cooperative programmes.

It can therefore be said that Spanish industry is forced to:

- Apply the proof of the principle of a given technology in a single operating prototype "whenever possible and technically profitable";
- Undertake a tremendous economical effort to the limit of its possibilities even to buy a certain technological package. When this happens, very expensive long term dependencies are created and our own technology is offered to other organisations which are, sometimes, our own competitors.

These facts put the Spanish industry at a clear disadvantage vis-à-vis its foreign competitors.

We, as industrialists, hope that the Spanish Administration will follow what is done in other EEC countries, particularly with regard to what concerns the aerospace sector, and will improve the financial support given to R&D activities.

THE SPANISH INDUSTRY OF ELECTRONICS FOR DEFENCE

José A.Perez-Nievas
President of C.E.S.E.L.S.A.

Due to the fact that I am professionally acquainted with this environment, I am focussing my lecture on the area of Electronics for Defence.

Any device or any system for Defence applications is more and more involved with electronics. Aircraft, tanks, battleships have been provided with electronic sensors. They are commanded by Command and Control Centres and their weapon systems are remotely controlled by sophisticated electronic devices. Furthermore, the Tactical and Strategic communications networks are electronic. Warning and Alert systems are electronic, as well as the essential countermeasures and so forth, up to a nearly endless list which would positively show the enormous importance of electronics in the Defence world.

The percentage of electronics products in the Defence estimates of neighbouring countries is about 33% with an upward trend. In 1987 Spain contracted 283,000 million pesetas (1,980 million US dollars) to equip our Armed Forces. About 70,000 million of them (583 million dollars) were devoted specifically to electronic applications.

Therefore, on considering the estimates of our Defence Department in respect of acquisitions, we're talking about one of the main potential development driving forces of the Nation's Industry.

Should this fact be utilized adequately, the benefit will be twice as much, because, on the one hand, the Defence Department will act as a natural promoter of National wealth by demanding equipment and systems and, on the other hand, the existence of industrial companies guarantees a degree of industrial independence and, therefore, sovereignty. For logical strategic reasons, dependence on foreign technologies and supplies should be avoided.

This unquestionable fact has contributed, in most of the nearby countries, to the birth and consolidation of important industries. We can all bring examples to mind. Some of you, who are from foreign countries, will most probably be thinking at this moment of a powerful industrial group which, due to its own technology, is participating more and more in the international markets related to this area. We all, you at least, can feel proud of this fact.

But let us consider what is the status of the Spanish Electronic Industry for Defence nowadays. Support for the development of a national industry comes only from the recent past. For those who are interested in a brief historical summary I would say that the treaty between our country and the USA for joint usage of Military Bases, which was agreed 34 years ago, represented a real technological loss for Spain. The USA offered to provide the technology, and this was agreed by the Spanish government. Military effort for the development of specifications was replaced by the selection of items from catalogues, and industrial companies stopped their design and development efforts and started assembling under licence or, even worse, just representing foreign companies.

So our effort has now to be greater than that of other countries. The Public Administration and industrial companies have to struggle to obtain what other countries already have and they have to be aware that sometimes it requires a strong commitment and support and that there isn't any other possible way but the one others have already taken. We must also be aware that the risk of making mistakes, as others have before, cannot be avoided if we are to achieve an international presence.

The fact that in Spain there are no internationally sized electronic companies at present, does not mean that there cannot be any in a 5 or 10 year term. This objective can be obtained by enhancing the ones already existing, which have demonstrated that they can fulfil their obligations, and by giving a chance to the new ones. The French President, General De Gaulle, made that decision 30 years ago, in the face of many apparently prudent but interested opinions, and was able to provide his country with today's enviable industrial network that competes or associates with equality with foreign firms, without being autarchical.

In the specific case of electronics, the state of the art changes so swiftly and depends so much on human creativity, requiring less and less enormous investments, that Spain can take care of the present technological gap in a few years.

And what route can a country like ours take? I would start with systems and unique equipment, because, although they look the most complex, they are quite accessible for a country with good academic levels like ours, and no great resources.

System design leads to equipment specification and equipment involves components. This is the most efficient way. If some day, Spanish Companies make a significant quantity of systems, an important part of the equipment going into the systems can be manufactured at home. This equipment would finally

include more and more components manufactured in Spain.

But our Administration's effort to achieve this aim is only recent and, from my standpoint, too poor so far.

It is necessary that both politicians and businessmen are aware of the role they have to play. I want to emphasize that in these few years it is unquestionably a fact that there now exist Spanish companies that have developed their own technology in areas as important as radar, simulation, electronic warfare and communications.

So what is to be our companies' rôle in the future, upon integration in the EEC and NATO? At present two main lines can be taken into account in my country. Firstly, generation, with our own effort, of national programmes to provide our Armed Forces with the equipment they need and bring them up to the level of other Armies. Secondly, the increasing requirements to participate in European programmes without interfering with the other partners' work. Neither one can be disregarded, and they have to be compatible, but it is necessary to emphasize, from my standpoint, the qualitative importance of the first one, which is the key to effective participation in the second and at the same level as other countries.

As I've already said, a country without a proper technological level would not contribute to a prosperous and technologically powerful Europe. Hence we all are interested in improving our level, the more the better, to bring our little contribution to the project of making Europe a world leader. For this purpose, there is a basic way: large national projects. All our neighbour countries have developed the power of their companies through that process. In Spain we have to follow their steps and this is the message Spanish businessmen are continuously telling the Government.

Then comes our collaboration in international programmes. As in any other country, the estimates of our Defence Department are quite limited, and we will have to select carefully the most fruitful ones for everybody. And they will unquestionably be those in which our participation is more significant and active and in the area where our knowledge allows us to collaborate at the same level as our partners.

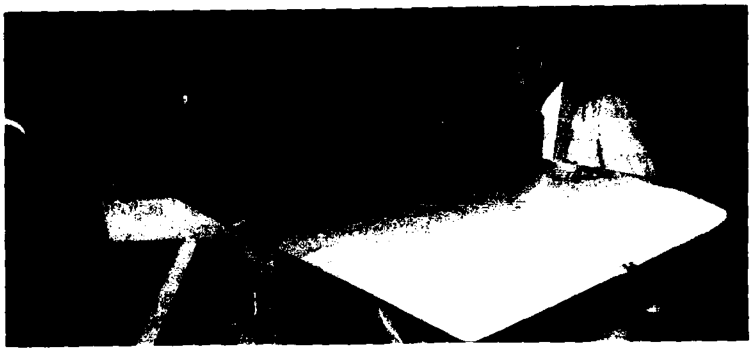
I can tell you that this is already taking place with some European programmes in which our industry is involved. I'd specially pinpoint two of them: The EFA programme and the 90s Frigate.

I consider especially important the active establishment of many partnerships in the first one and the very important activity our engineers are carrying out to date with negotiations and preparation of offers.

Up to a short time ago each country in Europe used to size up their industries just according to their national requirements. Now that they are associated they negotiate the necessary collaboration for a joint and powerful Europe. Both things will have to be done at the same time in Spain. This is our challenge. Time will tell us whether the process has been the right one or not.

Visit to CASA (Construcciones Aeronauticas S.A.)

An audio visual presentation of CASA and its activities was given first. This was followed by a tour of the factory at Getafe near Madrid, during which visits were made to the Final Assembly Section, where the C101 Trainer was being assembled and parts for Airbus A 320 wings are manufactured, to the Maintenance Section where major overhauls are carried out, on CASA aircraft and on others, including US Air Force aircraft, and to the Composites Section.



Visit to INISEL (National Company of Electronics and Systems)

The participants in this visit were welcomed by Mr Eduardo Moreno, the President of INISEL, and given an audio visual presentation on INISEL's work in the aeronautics and defence fields, followed by a more detailed description of the organisation and its structure. The presentations were followed by a tour in which the visitors saw, among others, recently developed automatic test benches for avionics, and the Space, Air Traffic Control and Avionics Departments.

Visit to INTA (National Institute for Aerospace Techniques)

After a general explanation of INTA and its research and development activities, the participants visited various research facilities including an anechoic chamber for antenna testing, the Missile Guidance Section, a test laboratory for photovoltaic cells and the Metal Fatigue Section.

LANGUAGE IN LUXEMBOURG

J.Christophory

The Technical Information Panel sponsored a Lecture Series on 'Evaluating the Effectiveness of Information Centres and Services' in 1988. At the presentation in Luxembourg Dr Christophory, Director of the National Library of Luxembourg, gave a short account of the linguistic history of Luxembourg and the present status of the three languages used there. It was thought that members of the AGARD Family would find it of interest and Dr Christophory kindly prepared this article for 'Highlights'.

The country of Luxembourg is over 1,000 years old. It became a countship in 963 A.D.; later (after 1354), it became a duchy within the Holy Roman Empire. The dividing line of the Germanic and the Romance languages, on which it was geographically situated, has largely conditioned its cultural development. Even though West Moselle Franconian, a Frankish dialect, is used by one-half of the Duchy, bilingualism has always prevailed. The Luxembourg princes were educated at the French court, and French has been the official language since the 15th century.

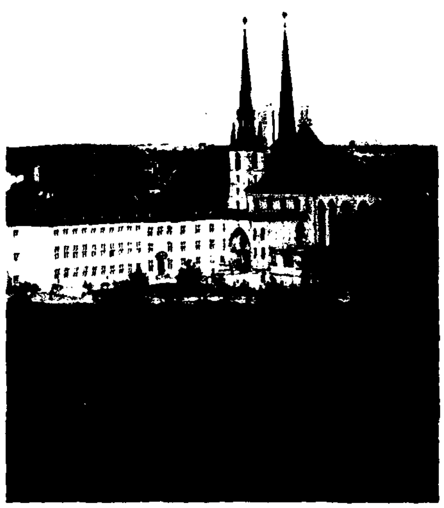
Luxembourg has lived under foreign domination for almost four centuries: first, under the dukes of Burgundy, then under the Habsbourgs. In the 16th and 17th centuries, it was part of the Spanish Low Countries, and later became part of the Austrian empire. Luxembourg, being situated in the extreme south of the Low Countries, was one of the poorest and culturally most neglected territories of that large configuration.

In 1795 it became the French Département des Forêts and in 1815, after the Congress of Vienna, the Grand Duchy of Luxembourg, personal property of the Dutch King William I. After three amputations (1659, 1815 and 1839) its size has been reduced to one fourth of its medieval territory, yet since the 14th century bilingualism has been its true characteristic.

At first sight Luxembourg's linguistic situation seems to lack any coherence. But this first diffuse impression quickly vanishes if you envisage the situation as the result of this long historical evolution at the dividing-point of two distinct languages and cultures. The ancient country of Luxembourg embraced both German-speaking and French-speaking territory (although this is no longer the case for the present Grand Duchy). Two shaping forces have determined Luxembourg's linguistic situation: (1) geographic and ethnic factors; (2) changing political components.

If, under Sigefroi, Germany influences still determined Luxembourg's orientation, this changed after 1196 with Ermesinde, when French culture clearly predominated at the court. Alliances and princely marriages corroborated these links and created strong francophile traditions which endured through the last two world wars.

In the choice of languages the attitudes of most Luxembourgers are based on extralinguistic motivations, which very often proceed from complicated political, psychological and sociological factors. Today the foreign observer notices in Luxembourg a curious juxtaposition or better, a "superposition", of three different idioms. All these tongues respond to a necessity and a certain scale of values. In everyday life, inside families and at every level of society, a single tongue is used, mostly for verbal communication: Luxembourgish.



The National Library of Luxembourg is in the centre of the City, next to the Cathedral.

Foreign observers have always been at a loss to pigeon-hole the language and have made most absurd and irrelevant comments about it.

A few minor examples to illustrate the case:

"... Luxembourgeois, a rapid tongue with inflections of both French and German overlaid with a dense incomprehensibility of its own." (David Hewson, *The Times*, May 11, 1981)

"The operative tongue is a jaw-breaking dialect." (*Fielding Travel Guide to Europe*, p.977)

"... the language is a kind of guttural German, not very different from that spoken around Trier." (Barry Dale, *International Herald Tribune*, Nov. 17, 1980)

We usually find Luxembourgish classified among the West-Germanic languages as a West Middle German dialect called Moselle Franconian (Moselfränkisch). Its historical development took place within the "westmitteldeutscher Raum" or the Rhenian Fan (Rheinischer Fächer) in the areas of Trier and Koblenz. It originated with the bold venture of the Salian Franks (North Sea Franks) and the Ripuarians (Rhenish Franks) who began settling in our region during the 3rd century A.D. The linguistic symbiosis between the West Franks and the Romans in northern Gaul after the Frankish conquests resulted in the creation of Luxembourgish.

Yet in written communication Luxembourgish could never replace the use of German or French. German is the language currently used in newspapers, eager to touch the greatest possible number of readers, but cultural articles or private and official announcements are written in French. Two francophonic newspapers, one French (Le Républicain Lorrain) and one Belgian (La Meuse) publish special editions in French for the Grand Duchy, which have a wide circulation.

French is the language of our courts: legal pleas, proceedings and sentences are pronounced, drawn up and printed in French. In Parliament most of the debates are held in Luxembourgish, but parliamentary documents and draft laws as well as their published texts are in French. But texts destined for wide public circulation are bilingual or in German only. As a rule French is used as far as possible, and German whenever it is indispensable for the less-educated members of the public to understand. In church, German is the primary language. But over the last years the use of Luxembourgish has been steadily gaining ground, especially for sermons and announcements. Administrators very often use German and French in a parallel way.

In primary schools and in the lower classes of lycées German tends to be the language of instruction in science subjects. Its place is being gradually taken over by French in the middle and upper classes. Luxembourgish will not normally be used for teaching purposes, but only for informal conversation. On the other hand, nobody would ever speak German in public, unless addressing a German guest.

According to article twenty-four of the royal decree of 3 October 1841, notaries must use the language chosen by the two parties. Article twenty-nine of the Luxembourg Constitution of 1848 says, "The use of the French and German languages is optional.Their use must not be restricted". During a revision in 1948, the text was changed to "the use of the language in the field of adminstration and justice will be ruled by law".

In 1984, on February 24th, the following law was finally passed. It mentioned Luxembourgish for the first time ever, and declared it to be the national language of the Luxembourgers. Moreover it specified the language situation in the domains of administration and legislation in the following way:

Art.2 — The legislative language

Laws and bye-laws are worded in French. If there is a translation of legal instructions and regulations, then only the French version is considered as authentic.

Should bye-laws, other than those quoted in the first paragraph above-mentioned, be issued by governmental bodies, boroughs or public establishments in a language other than French, then only the language used by this establishment shall be authentic.

The present article does not depart from the rules applicable to international conventions.

Art. 3 — Administrative and judicial languages

For administrative matters, contentious business or not, and for judicial matters, either French, German or Luxembourgish may be used without prejudice to the specific provisions pertaining to certain matters.

Art. 4 — Administrative petitions

If a petition is worded in Luxembourgish, French or German, administrative bodies should as far as possible answer it in the language used by the applicant.

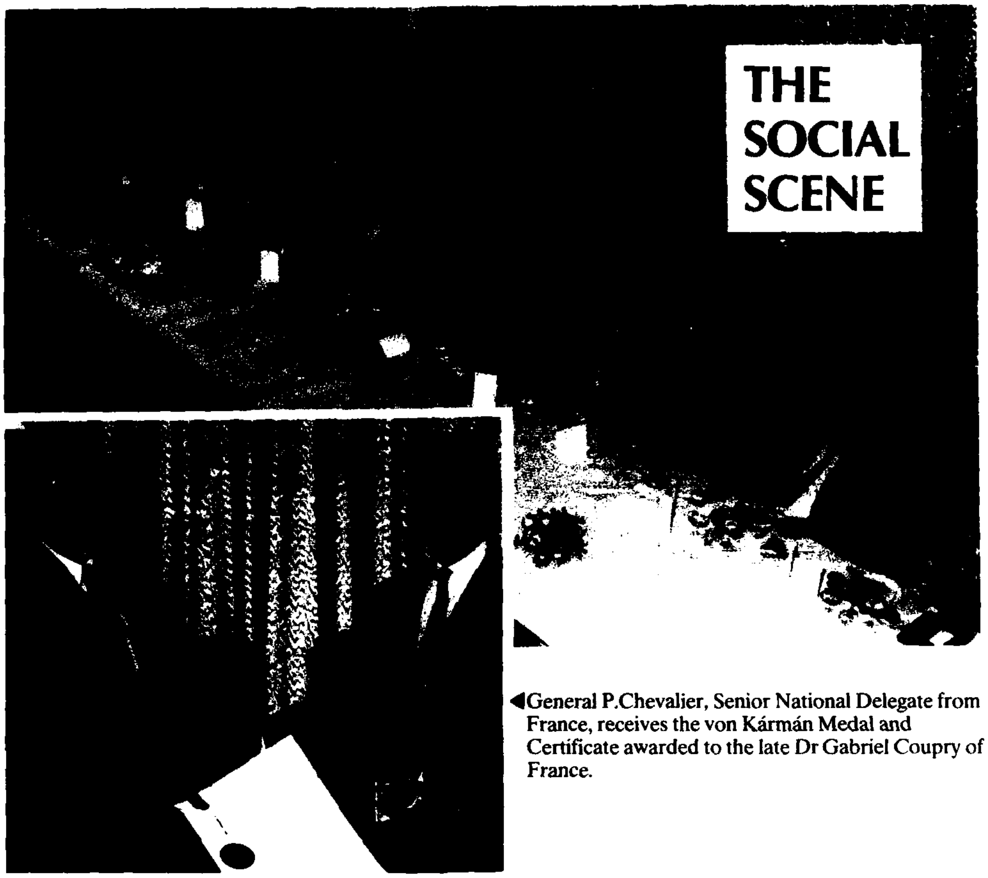
DR JUL CHRISTOPHORY was born in Luxembourg in 1939. He studied Humanities in Luxembourg and Latin, French and English at Strasbourg and Paris, and was awarded a Doctorate by Kings College, London in 1966 for his thesis on "Patterns of Isolation and Menace in Harold Pinter's Dramatic Work".

Before being appointed Director of the National Library of Luxembourg, Dr Christophory was Professor of French Literature at Miami University, Oxford, Ohio, and at the European Centre in Luxembourg, and a teacher of English at the Lycée Michel-Rodange.

Dr Christophory has made various contributions on aspects of modern drama to the "Luxemburger Wort", the "Nouvelle Revue Luxembourgeoise" and the "Pages de la S E L F" (Société des Ecrivains de Langue Française de Luxembourg). He is the author of a bilingual phrase-book of Luxembourgish, "Sot et op Letzebuergesch", and of a bilingual work on Luxembourgish Grammar and Anthology, "Mir schwätze Letzebuergesch". He has written various other books about the language and the people of Luxembourg and was the Editor-in-Chief of English-Luxembourgeois and Portuguese-Luxembourgeois Dictionaries.

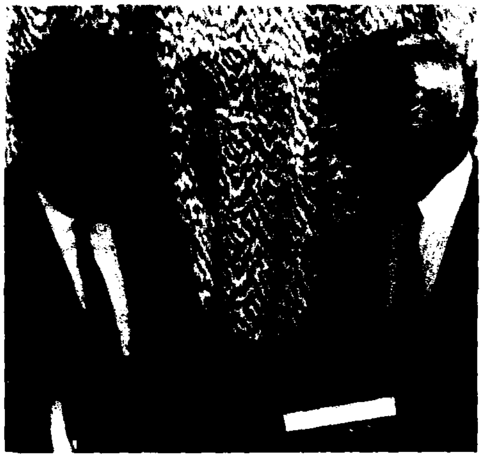
He has travelled widely over Europe and the United States as a student tour guide for the American Student Information Service and is fluent in five languages including Russian. He is married with two children.

THE SOCIAL SCENE



◀General P.Chevalier, Senior National Delegate from France, receives the von Kármán Medal and Certificate awarded to the late Dr Gabriel Coupry of France.

Mr Javier Alvarez Vara, President of C.A.S.A., hosted a cocktail party for the Delegates. He is seen here with Admiral Geiger and General Bautista Aranda, Spanish National Delegate. ▶



◀ His Excellency Señor Rafael de la Cruz Corcoll, Spanish Secretary of State for Defence was presented with an AGARD plaque by the Chairman of AGARD, Rear Admiral Robert Geiger.

▲

Drinking a toast to AGARD are General Bautista, Dr Flax, Honorary Vice Chairman of AGARD, Señora Viuda de Marin, widow of the former Spanish National Delegate, and Admiral Geiger.

▲

Mr Jan van der Bliek, Director of AGARD and Señora de la Cruz Jimenez, wife of Lt General de la Cruz Jimenez, Chief of Materiels Command of the Spanish Air Force, enjoy their meal while, to their left, Señora de Bautista chats to Professor Gero Madelung, former Chairman of AGARD.

A BRIEF HISTORY OF ROCKETRY

A.J.Cruttenden

One of the venues of the revised version of Lecture Series 150 — Design Methods used in Solid Rocket Motors — presented in April 1988, was London, United Kingdom, where participants were welcomed by Dr Alan Cruttenden, then a UK member of the Propulsion and Energetics Panel. After his formal welcome he said a few words about the history of rocketry, which we thought might interest readers of 'Highlights'.

Rockets were originally invented by the Chinese over 2000 years ago and used in their fire bolts and fire arrows. It was not until the 13th century that the technology of the free flight rocket emerged and it soon reached Europe via India, Arabia and Byzantium: the Europeans took it up rapidly, and there are reports of them being used in

1258 at Cologne
1281 at Forli
1324 at Metz
1327 by the English against the Scots

As the technology of guns developed, rockets fell into disuse as weapons after only a century of service. In the 18th century, British activities in India renewed our contact with rockets which were used by the Indians, but they were not regarded as being very effective. Sir William Congreve, after a considerable period of development, produced an effective weapon. Congreve developed and produced his rockets at the Royal Laboratory at Woolwich, later known as Woolwich Arsenal in what is now South-East London, where his father Lieutenant-General Sir William Congreve was the Comptroller. A principal source of supply of the gunpowder used in both the rocket motor and in the warhead was the Royal Gunpowder Factory at Waltham Abbey, which later became the centre for the development of rocket propellants that are used in our present-day rocket motors, so we can trace our modern industry back to those origins from that side as well as having a more recent history of manufacturing rockets that were developed at Woolwich in our ordnance factories.

Congreve rockets were first used in service in bombarding Boulogne from small boats in 1805. They were similarly used during the siege of Copenhagen in 1807—1809 and on land by the Rocket Troop of the Royal Artillery at the battle of Leipzig in 1813. At the same period we were also having a little disagreement with the Americans, and two incidents involving rockets are of particular interest: the first at the battle of Bladenburg in August 1814 where the intensive fire of rockets against Stansbury's brigade led to an almost general rout causing the capture and burning of Washington DC. There was little but the walls left of the offical residence of the President, and when it was rebuilt it was painted white to hide the burn marks: it has been called the White House ever since. The second incident involved the use of rockets during the night of 13—14 September 1814 at the unsuccessful attempt to capture Fort McHenry in Baltimore. The vivid spectacle of night-firing rockets inspired Francis Scott Key to include the well-known phrase "by the rockets' red glare" in a commemorative poem that he wrote soon afterwards. The poem "The Star-Spangled Banner" was very popular and was later adopted as the National Anthem of the USA.

We are therefore eternally grateful to the Americans for what may be regarded as our longest-running free advertisement, and would ask them not to change their National Anthem! We are very proud of our rockets' contribution to the history of the USA, even if they were not exactly appreciated by the Americans at the time!

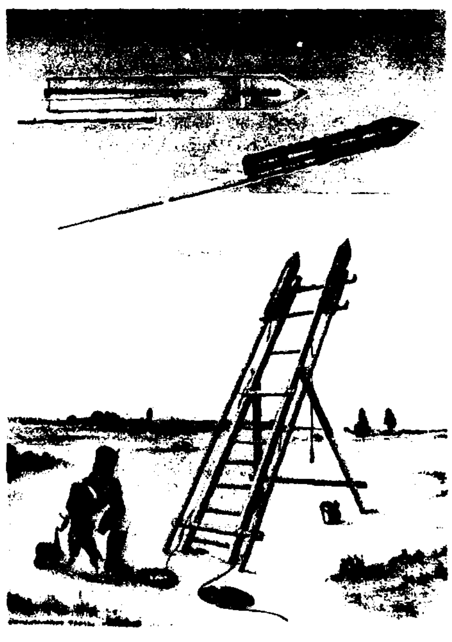


Fig.1 Congreve Rockets, as used by the Rocket Troop of the Royal Artillery

Now Congreve's rockets used sticks fastened to the side of the motor cases just like today's firework display rockets, and were not very accurate. William Hale of the USA improved the breed by dispensing with the stick and spinning the rockets. But then rockets entered another period of decline from which they only fully emerged in World War II: by the end of the war, the USA was producing rockets at the rate of over 1 billion per year. Although numbers produced have declined markedly since then, rockets are quite clearly here to stay. We have moved on from Congreve and no longer use gunpowder for the propellant and iron for the motor case. Having in a fashion covered the first 2000 years of rocketry, I have great pleasure in handing over to the Lecture Series team to hear about the current state of the art.

ALAN CRUTTENDEN was born in Hastings, Sussex in 1938. He read Natural Sciences and Chemical Engineering at Cambridge University where he was at the same college as Newton. (His Swiss wife Susi attended the same Canton School as Einstein but neither has any other association with mathematical genius.) He joined the Ministry of Aviation at its Rocket Propulsion Establishment, Westcott in 1963: he has been based there ever since. His early work on liquid propulsion systems included research into small combustors for attitude control systems, theoretical analysis of turbulent combustion measurements and modelling of packaged liquid rocket motors and recoiless guns. He was subsequently responsible for conceptual design and assessment of liquid rocket motors.

In 1975 he became Head of the Assessment Section of the Rocket Motor Executive, whose main business was solid rocket motors. He was the UK official side adviser on propulsion for a wide variety of national and international missile programs including ASSM, NATO 6S, ASRAAM and AST 1228 (HARM vs ALARM).

With the privatisation of the Royal Ordnance Factories plus some MOD R&D establishments, he is now working in the Future Systems Group of Royal Ordnance as Manager Collaborative Studies and Intelligence. NIAG studies, NATO watching and collaborative Studies and Intelligence. NIAG studies, NATO watching and collaborative weapon system programmes such as NAAWS, FAMS & MSAM are now his principal interests rather than propulsion per se. He was a member of the Propulsion and Energetics Panel from 1982 to 1988.

FLIGHT TESTING AND FLIGHT RESEARCH:
FROM ICARUS TO THE 'SOUND BARRIER'

R.P.Hallion

One of the papers presented at the Flight Mechanics Panel's Symposium on 'Flight Test Techniques' held at Edwards Air Force Base in October 1988 was a historical survey of flight testing. The complete paper will be printed in AGARD Conference Proceedings CP 452, to be published in 1989, but it was considered that the earlier material would be of interest to the readers of 'Highlights'. The finishing date of the first flight through the 'Sound Barrier' was chosen because that barrier proved to be as mythical as the starting point — the flight of Icarus.

INTRODUCTION

Since the beginning of flight, aerospace vehicle design has depended upon data gathered from the performance of actual flight vehicles. This flight testing and flight research process has led to today's air-and-space-craft, and points the way for future flight. Within this process, the flight test planner, test pilot, and flight test engineer occupy positions of critical importance.

UP TO WORLD WAR I

Flight testing and flight research are as old as flight itself. There is the myth of Icarus, who experienced structural failure from heating effects, leading to subsequent loss of control. More factually, Eilmer of Malmesbury, a Benedictine monk (and the first test pilot worthy of the name), made a short gliding flight marred by a landing accident from a loss of longitudinal control about 1000 A.D., from Malmesbury Abbey in Wiltshire, England. In the Nineteenth Century, a coachman and a small boy flew for a few yards in experimental gliders designed by Sir George Cayley, a pioneer generally recognized as the "Father of Aerodynamics" as well as the individual who first postulated the modern airplane configuration (wings, fuselage, and a tail group). Then, of course, comes that towering figure of early flight testing, Otto Lilienthal. In 1896, the year of his death in a glider accident, he wrote, *"One can get a proper insight into the practice of flying only by actual flying experiments."* A trained mechanical engineer, he combined shrewd theoretical studies of birdflight with his own bold experiments with a series of monoplane and biplane gliders. He recognized the price flight researchers are sometimes required to pay, remarking that "Sacrifices must be made," an especially appropriate and poignant epitaph for his own career. Lilienthal profoundly influenced subsequent researchers, notably Octave Chanute, and Wilbur and Orville Wright.

The Wright brothers deserve credit for developing the first powered and manned aircraft capable of making a sustained and controlled flight. They were brilliant, intuitive flight researchers who recognized the vital partnership between theory, ground testing, and research aloft, and the need for acquiring reliable data. Wilbur Wright compared the testing of an airplane to riding a fractious horse. He stated, *"If you are looking for perfect safety you will do well to sit on a fence and watch the birds, but if you really wish to learn you must mount a machine and become acquainted with its tricks by actual trial".* Beginning with theoretical studies, the brothers moved to kite-gliders. When early designs proved disappointing, they refined their thinking and improved their understanding by ground testing including use of a small wind tunnel. Then, with their

Figure 1: 10:35 a.m., 17 December 1903: Orville Wright (with Wilbur running alongside) fulfills a dream of centuries, completing the world's first powered, sustained, and controlled flight.

Photo courtesy National Air and Space Museum, Smithsonian Institution

confidence bolstered by flight trials with the 1902–1903 glider, they built the epochal 1903 powered machine. On December 17, 1903, the era of powered flight dawned, a triumph of flight research that fulfilled the dream of centuries. Orville, the test pilot, summarized the flight as follows:

> *"Wilbur ran at the side, holding the wings to balance it on the track. The machine, facing a 27-mile wind, started very slowly. Wilbur was able to stay with it until it lifted from the track after a forty-foot run. The course of the flight up and down was exceedingly erratic. The control of the front rudder (canard elevator — ed.) was difficult. As a result, the machine would rise suddenly to about ten feet and then as suddenly dart for the ground. A sudden dart when a little over 120 feet from the point at which it rose into the air, ended the flight. The flight lasted only twelve seconds, but it was nevertheless the first in the history of the world in which a machine carrying a man had raised itself by its own power into the air in full flight, had sailed forward without reduction of speed, and had finally landed at a point as high as that from which it started."*

For its time, this is a model test flight report. It presents the test conditions, a critical analysis of the airplane's stability and control, and, finally, a summation of the flight's significance. Nowadays, of course, such information is presented accompanied by extensive quantitative analysis, but the ideas behind the report are the same. One can compare the very successful and practical approach to flight research taken by the Wrights (and, to a lesser extent, by Lilienthal and Chanute) to the overblown methods of a Samuel Langley or Hiram Maxim, who went to eleaborate lengths on paper and with costly testbeds to develop what were ultimately grotesque and unsuccessful vehicles.

CONSOLIDATION

By the time of the First World War, flight testing had already taken on the trappings of professionalization. Designers, pilots, and engineers worked closely together, and emphasis shifted from choosing just good "stick-and-rudder" men as test pilots to choosing good stick-and-rudder men with solid technical credentials. In Great Britain, Edward Busk had introduced scientific methods to flight testing at Farnborough. After Busk's tragic death in an aircraft accident, Frederick Lindemann, William Farren, and Henry Tizard, trained scientists all, continued this trend. Lindemann — who eventually became Prime Minister Winston Churchill's scientific advisor during the Second World War — conducted a major experimental study of spinning, complementing a theoretical analysis of the problem that he had already undertaken.

This "scientific" influence extended across the Atlantic as well, to early American test pilots such as Edmund T. "Eddie" Allen (who flew for the US Army at Britain's Martlesham Heath testing centre), and Thomas Carroll of the National Advisory Committee for Aeronautics (NACA). The NACA, created in 1915 by an act of Congress "To supervise and direct the scientific study of the problems of flight", did much to place American flight testing on a firm scientific basis. The NACA began its flight research activities in 1919 at the Langley Memorial Aeronautical Laboratory (mow NASA Langley Research Center) using Curtiss JN-4H Jenny trainers.

Two years earlier, the American military services recognized the unique importance of flight testing by creating specialized test centers, beginning with the establishment of Anacostia Naval Air Station in 1917. The next year, 1918, the Army established McCook Field in Ohio as the Signal Corps' experimental laboratory. In fact, both military services had a heritage of flight research predating the creation of these two centers, but the creation of these centers marked an important milestone in the evolution of American military aeronautics. Anacostia remained the Navy's flight testing center until the establishment of the Naval Air Test Center at NAS Patuxent River in 1943. Likewise, McCook enventually gave way to Wright Field, and Wright, in turn, to Edwards Air Force Base, as the air service's premier flight testing center. These early centers were no less professional in their approach to flight testing and flight research than their successors are in the present day. For example, McCook pilots and engineers submitted detailed reports on new aircraft, with remarks on control forces, control effectiveness, stability, handling characteristics, and the efficiency of cockpit instrument displays.

Professional flight researchers and aircraft designers recognized that the devil-may-care "show me the stick and I'll fly it" test pilot was a dangerous anachronism, who was disappearing in fact, if not in fiction. In 1920, Edward P.Warner and F.H.Norton of the NACA wrote that *"Test flying is a highly specialized branch of work, the difficulties of which are not generally appreciated, and there is no type of flying in which a difference between the abilities of pilots thoroughly competent in ordinary flying becomes more quickly apparent"* Warner, an individual who greatly influenced the subsequent history of American flight testing, stressed giving the test pilot training in analytical methods.

During this time, a number of Federal and private organizations started issuing formal flight testing handbooks and instruction guides for prospective flight test crews. One such, by Army Captain George Patterson, quaintly warned that test crews should not use pens to record information, "as the ink will freeze at high altitudes". In 1927, Lawrence V.Kerber (the former director of flight testing at Wright Field) and W.F.Gerhardt issued a pioneering guide, *A Manual of Flight Test Procedure*, leaving no doubt as to how exacting the flight testing process was becoming.

Figure 2: In 1920s and 1930s, air-racing aircraft such as this Curtiss R-8 (shown with test pilot Alex Pearson) served in a manner analogous to the post-World War II "X-series" of research aircraft and technology demonstrators.

Photo courtesy Aeronautical Systems Division History Office, Wright-Patterson AFB

MAJOR TECHNICAL ADVANCES

During the 1920s, flight research and flight testing advanced rapidly, keeping pace with major changes affecting the development of aeronautical technology. Among the revolutions transforming aviation at this time were the streamline doctrine, which led to greater emphasis on aerodynamics and efficient high-speed high-altitude flight; the development of more powerful and lightweight engines, particularly the high-performance radial engine; and the transformation of the aircraft structure from wood to wood-and-metal, and eventually to all-metal. Flight researchers examined problem areas related to all of these subjects, and many others as well. They studied how aircraft behaved in accelerated flight, flew to increasingly higher altitudes, evaluated new devices for aircraft, made the first landings on sea-going aircraft carriers, and developed new flying techniques and design criteria.

In March 1924, for example, Army test pilot James H. "Jimmy" Doolittle test-flew a Fokker PW-7 experimental fighter biplane so that aeronautical engineers could better design future pursuit biplanes to withstand the forces of high-speed abrupt maneuvers. During one 7.8g dive pullout, the rear wooden surface of the Fokker's upper wing cracked, indicating that the PW-7 had reached its limit load. This, incidentally, refuted the then-commonly held belief that wings fail in a pullout by shearing backwards towards the tail. Doolittle himself is a good example of the engineering test pilot. He was not an unthinking daredevil but, rather, a shrewdly calculating professional who eventually earned an M.S. and Sc.D. in aeronautical engineering (based upon his flight testing studies) from the Massachusetts Institute of Technology. Meticulous and thorough test reports became a Doolittle hallmark, and a model for future test pilots to follow.

Flight researchers examined new aircraft equipment and design theories by testing such developments on aircraft in actual flight. The variable-pitch propeller, the Handley Page wing flap and slat, the smaller ethylene glycol (vs. water) radiator, and the exhaust driven turbosupercharger were all thus experimentally verified. In 1928, NACA engineers tested an experimental radial engine cowling on a modified Curtiss AT-5A Hawk. As designed, the uncowled Hawk had a maximum speed of 118 mph. With the cowling, its speed jumped to 137 mph (equivalent to the addition of 83 hp). Such results could not fail to impress the aircraft industry, and the "NACA cowling" soon became a standard installation on radial engine aircraft.

The NACA also pioneered in instrumenting aircraft to record flight conditions. This early work eventually led to a document of major significance, NACA Report 369, by C.H.Dearborn and H.W.Kirschbaum, entitled "Maneuverability Investigation of the F6C-3 Airplane with Special Flight Instruments". This study, which the NACA completed in 1930, was the first detailed examination of aircraft handling qualities ever done in the United States. Onboard recording instrumentation had provided a precise record of the airplane's behavior during loops, pullups, pushdowns, and abrupt rudder maneuvers. The results were then reduced to easily understood data

that aircraft designers around the world could put to use in engineering new aircraft.

The Daniel Guggenheim Fund for the Promotion of Aeronautics made a number of significant contributions to aeronautical education, technology, and flight safety during its short four-year existence from 1926 to 1930. In particular, two of its more important activities involved flight testing and flight research in the fields of so-called "blind" (instrument) flying and short-takeoff-and-landing (STOL) aircraft design. The Fund created a special "Full Flight Laboratory" at Mitchel Field, Long Island, in conjunction with the Army Air Corps and the Bureau of Standards (which was deeply committed to studying the technology of radio navigation and blind landing aids). On September 24, 1929, Fund test pilot Jimmy Doolittle (on loan from the Army) completed the world's first blind flight from takeoff to landing, using three new aviation instruments developed at the behest of the Fund: the Kollsman precision altimeter, the Sperry gyrocompass, and the Sperry artificial horizon. In 1930, the experimental Curtiss Tanager STOL biplane won the Guggenheim International Safe Aircraft Competition (a British design, the Handley Page Gugnunc, finished a very close second), in a competition notable for the wide and exciting diversity of technological approaches taken to achieve the goal of a truly STOL aircraft. The information acquired during this noteworthy competition provided valuable design criteria for subsequent STOL aircraft.

HIGH-ALTITUDE FLIGHT

The 1930s witnessed an expansion of work undertaken in the 'twenties, notably in the areas of high-altitude flight, rotary-wing research (particularly the transition from the autogiro to the genuine helicopter), and in the increasing professionalization of the test pilot. To further the desires of aircraft designers to develop fast and efficient long-range high-altitude aircraft, various aeronautical research establishments around the world supported extensive studies of the upper atmosphere. Consequently, engineers and inventors sought ways to provide pilots and flight crews with adequate physical protection. This experimentation took the form of high-altitude balloon flights (some marred by tragedy), and experiments with pressure suits and pressure cabins.

In the United States, Wiley Post climaxed a long pressure suit development program in March 1935 by flying a modified Lockheed Vega monoplane, the *Winnie Mae*, at over 30,000 feet from Burbank, California, to Cleveland, Ohio. Post's experimental full-pressure suit, though awkward and uncomfortable, worked very well, and can be considered the ancestor of the modern full-pressure spacesuit. Later that year, Army pilots Albert Stevens and Orvil Anderson reached 72,395 feet while piloting the balloon *Explorer II*. Finally, in 1937, the Army flew the XC-35, a derivative of the twin-engine Lockheed Electra transport, equipped with turbosupercharged engines and pressurized cabin. During extensive testing at Wright Field, the XC-35 validated the pressure cabin concept, anticipating all modern pressurized civilian and military aircraft.

By the end of the decade, the world's first airline designed for pressurized operation, the Boeing Model 307 Stratoliner, was already flying. Flight research had produced results enabling aircraft designers to build high altitude aircraft with confidence. Subsequent research, particularly by then-Colonel W.Randolph Lovelace of the Aero-Medical Laboratory at Wright Field and the Boeing company, confirmed the practicality of developing aircraft and training aircrews to operate routinely above 30,000 feet. This work had an important impact on post-World War II commercial aircraft operations in addition to its obvious military significance.

ROTARY WING AIRCRAFT

Development of rotary-wing aircraft made major strides in the 1930s, building upon earlier development of the autogiro by Spanish engineer Juan de la Cierva in the 1920s. With its unpowered rotor system, the autogiro could not accomplish the true vertical takeoff and landings possible with the genuine helicopter, and thus, despite its remarkable STOL performance, remained more an indication of what still needed to be done than as a fulfilment of promise itself. Rudimentary helicopters appeared during the 1930s, typified by the coaxial *Gyroplane Laboratoire* of Louis Bréguet and René Dorand and the twin-rotor Focke-Achgelis Fw 61 of Heinrich Focke, but it remained for expatriate Russian designer Igor Sikorsky to develop the helicopter into a practical reality, beginning with his VS-300 testbed. The VS-300 made its first tethered ascent in 1939, and months of thorough exploratory and developmental flight testing were required before it completed its first successful free flight on May 13, 1940. Further experimentation to improve its controllability resulted in Sikorsky developing a totally satisfactory control system that subsequently appeared on the Sikorsky R-4, the world's first production helicopter. Once again, flight testing had refined a good concept into a workable production system.

Complementing this developmental work were analytic studies by the NACA using a variety of early autogiros and helicopters. The NACA had begun its rotary-wing flight testing research with a Pitcairn PCA-2 purchased in 1931, averaging two flights per week over the next five years. The NACA trained a coterie of Army personnel in rotary-wing flight testing methods who then returned to the Service and established an acceptance testing program, freeing the NACA to concentrate on research. Subsequent NACA work emphasized research on controllability,

Figure 3: The Focke-Achgelis Fw 61 was a significant pioneering technology demonstrator on the road to practical rotary-wing flight, and made a number of successful flights that attracted wide publicity.
Photo courtesy author's private collection

rigid rotors, blade motion, and rotor dynamics and loads. NACA's work in this field accelerated the development of more sophisticated helicopters after the Second World War, and presaged the extensive work undertaken by the NASA on helicopters and prop-rotor V/STOL technology, perhaps best exemplified by the recent Bell XV-15 tilt-rotor program.

PROFESSIONALISM AND TRAINING

A series of sensational motion pictures caused the 1930s public to regard the test pilot as a short-lived wild character with no concern for personal safety, who had overdeveloped qualities of foolhardiness and underdeveloped qualities of common sense, what professional flight testers scorned as a "high guts to brains ratio". The worst and most influential of these films was *Test Pilot*, staring Clark Gable, Spencer Tracy, and Myrna Loy. This unfair and demeaning portrait enjoyed then — and still enjoys, to some extent — wide acceptance.

Serious test pilots, such as Eddie Allen, wrote refutations that never quite succeeded in catching up to the myth. Commenting on the demise of the "here goes nothing" approach to test flying, Allen stated that *"Under the changing conditions of increasing knowledge, fatalistic risk taking becomes ignorant recklessness"*. Unfortunately, occasionally a test pilot *did* take a foolish chance, and endow the myth with the trappings of veracity. Contract test pilot Jimmy Collins had popularized the myth in his own best-selling book *Test Pilot*, and tragically fulfilled it shortly thereafter by crashing the experimental Grumman XF3F-1 biplane fighter during a rash and ill-judged dive pullout that overstressed the airplane. Such actions demonstrated only too well that a test pilot must be thoroughly acquainted with the potential dangers stemming from his actions.

By the early 1940s, the contract test pilot, a free-lancer who flew for a variety of companies, was increasingly an anachronism, though some of these individuals — such as Eddie Allen himself, and Vance Breese — were truly outstanding airmen. The future belonged to the careerists — the test pilots who flew for the government or for private industry. Increasingly, then, a need arose to train and furnish such men to the aeronautical community, endowing them with standardized training and strong technical backgrounds.

Out of this need, and particularly from the urgency of Second World War demands, emerged the first test pilot schools. Great Britain created the Empire Test Pilots' School (ETPS), where prospective test pilots could receive a thorough grounding in flight test procedures. In the United States, the Navy followed with creation of the Naval Test Pilot School at Patuxent River, and the Army Air Forces started a similar school at Vandalia Airport, near Wright Field. After the Second World War, the USAF moved this latter school to Edwards Air Force Base. (Other such schools followed, notably in France, and recently a new civilian school, the National Test Pilot School, has begun operations at Mojave, California, in the midst of the Antelope Valley's flight testing nexus.)

Neatly fitting into this manifestation of interest in ensuring the professional standards of flight test pilots was the work of the NACA. Late in the 1930s, Hartley A.Soulé and Robert R.Gilruth of the Langley laboratory began an extensive investigation aimed at

deriving a standard set of guidelines within the field of aircraft stability and control so that test pilots, flight test engineers, and designers would all speak a common "language". This resulted in the issuance of a landmark 1941 report (NACA Report 755) by Gilruth entitled *"Requirements for Satisfactory Flying Qualities of Airplanes"*, issued in 1943.

After the Second World War, the NACA continued its efforts to define standard pilot rating criteria. Test pilot George E.Cooper of the NACA Ames Aeronautical Laboratory derived a ten point pilot opinion scale which (in its original form) rated aircraft performance as "Satisfactory" (1—3), "Unsatisfactory" (4—6), "Unacceptable" (7—9), and "Unprintable" (10). In expanded and refined form, of course, this became the justly famed Cooper-Harper scale, used world-wide for the evaluation of new aircraft.

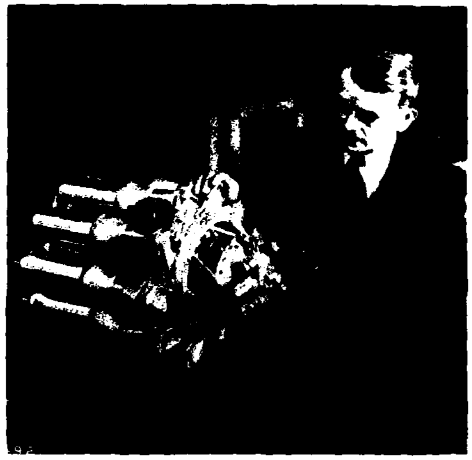


Figure 4: More than any other single individual, Frank Whittle, a Royal Air Force test pilot, triggered the turbojet revolution with his postulation and subsequent development of the centrifugal flow gas turbine engine.

Photo courtesy National Air and Space Museum, Smithsonian Institution

TURBOJET AIRCRAFT

Aside from service testing of military airplanes for wartime duty, the major challenges of aeronautical development in the 1940s were building upon the turbojet revolution and "breaking" the so-called sound barrier. The turbojet revolution was the product not of the aero-propulsion community but, rather, from individual inventors who built small demonstrator powerplants and flew them in rudimentary research airplanes. Only after demonstrating the potentialities of the gas turbine in such fashion were these investors and their backers able to convince unenthusiastic engine manufacturers and governments to support further turbojet development.

The two major figures in gas turbine research were the British test pilot and engineer Frank Whittle, and the German physicist Hans von Ohain. Shrewdly aligning himself with maverick German industrialist Ernst Heinkel, von Ohain was able to undertake development of the Heinkel He 178 technology demonstrator, which completed the world's first jet flight on August 27, 1939. Whittle's work resulted in the Gloster E.28/39, which flew in May 1941. Surprisingly, in the light of outstanding early turbosupercharger work, the United States came in third in the jet engine race, behind Nazi Germany and the United Kingdom. On October 1, 1942, Bell test pilot Robert M.Stanley ushered in the American jet era with a brief flight in the experimental Bell XP-59A Airacomet. So secret was this program (essentially a blending of an American airframe with Whittle engine technology imported from Great Britain) that all tests were conducted in the remote, barren surroundings of Muroc and Harper Dry Lakes. Indeed, at one point, security personnel disguised the plane with a bogus propeller.

The XP-59A soon gave way to the Lockheed XP-80 Shooting Star, first tested at Muroc in early 1944. This latter aircraft, of course, eventually spawned one of the most successful families of jet airplanes, the P/F-80 fighter, T-33 trainer, and F-94 interceptor family. Development of the P-80 occurred too late to permit its introduction into combat, though both Germany and Great Britain placed jet aircraft into operational service (the Nazi Me 262, Ar 234, and He 162, and the British Gloster Meteor) before war's end.

The US Navy also pursued jet development, and on July 20, 1946, Lt. Cmdr. James Davidson landed the prototype McDonnell SFD-1 Phantom, a twin-jet design, aboard the carrier USS *Franklin D. Roosevelt*, sending the Navy into the jet age.

With 500+ mph jet speeds, the time available to pilots to make critical decisions decreased markedly, and flight test personnel, accustomed to testing piston-powered aircraft, had to institute the special procedures for use with jets. Bell engineer Benson Hamlin prepared the first guide to gas turbine aircraft testing, *Flight Testing Conventional and Jet-Propelled Airplanes*, in 1946.

THE AIRCRAFT AS A RESEARCH TOOL

The inability of 1940s wind tunnels to furnish reliable transonic aerodynamic information, together with the well-publicised loss of several test aircraft from so-called "compressibility" (most notably Ralph Virden in a Lockheed P-38), led the NACA and the military services (in conjunction with private industry) to undertake joint transonic and supersonic research aircraft development programs, generating the famed postwar "X-series" of experimental airplanes. The plane itself now became a unique research tool, using the sky as a laboratory. These American efforts mirrored equivalent efforts abroad, notably by Great Britain and Nazi Germany.

Along the way, various stop-gap methods of research were attempted, particularly the use of modified bombers to drop falling-body aerodynamic shapes, rocket-propelled models, and experiments with diving fighters. One of the most interesting interim test methods involved the so-called "wing flow" method of research, using a small model mounted on a balance mechanism installed in the gun bay of a modified P-51 Mustang. NACA pilots would dive the Mustang to over Mach 0.7, and the behavior of the small model in the resulting accelerated transonic flow would be recorded by onboard instrumentation for subsequent analysis. American researchers dived P-38, P-47, and P-51 fighters as high as Mach 0.82, and German investigators took Bf 109, FW 190, Me 163, and Me 262 fighters to as high as Mach 0.85. Test pilot A.F.Martindale of the Royal Aircraft Establishment, however, achieved Mach 0.9 (±.01) in a Spitfire Mk XI during carefully conducted flight testing at Farnborough in 1943. Starting at an altitude of 40,000 feet, he attained an airspeed of 610 mph at 29,000 feet before initiating a 2.2g pullout.

All of this work, with models, falling bodies, and diving fighters, encouraged proponents of piloted reseach aircraft that could undertake research missions in level flight, without the time constraints and associated hazards present when diving towards the earth in a buffeting and marginally controlled aircraft.

The evident great interest of German aerodynamicists in high-speed flight planforms such as the swept, delta, and tailless configurations vindicated the work of Allied investigators who had studied such designs, and also stimulated postwar development of new ones. But the problem of transonic flight remained. Geoffrey de Havilland Jr perished in the crash of the tailless De Havilland D.H. 108 Swallow research airplane when it broke up in the midst of a violent longitudinal pitching oscillation at approximately Mach 0.87; his death coincided with a British governmental decision to abandon construction of specialized transonic research aircraft, notably the Miles M.52, on grounds of safety and economy.

The first manned supersonic flight occurred on October 14, 1947, when Air Force test pilot Charles E. "Chuck" Yeager reached Mach 1.06 (approximately 700 mph) at 43,000 feet, over the Mojave Desert near Muroc, flying the rocket-propelled and air-launched Bell XS-1. The significance of this accomplishment, considered at the time the most important flight since that of the Wrights at Kitty Hawk, cannot be overemphasized. Aviation science had crossed the invisible threshold to flight faster than sound, and the notion of a "sound barrier" crumbled into ruin. The test pilot subsequently wrote:

> *"With the stabilizer setting at 2° the speed was allowed to increase to approximately .98 to .99 Mach number where elevator and rudder effectiveness were retained and the airplane seemed to smooth out to normal flying characteristics. This development lent added confidence and the airplane was allowed to continue to accelerate until an indication of 1.02 on the cockpit Mach meter was obtained. At this indication the meter momentarily stopped and then jumped to 1.06 and this hesitation was assumed to be caused by the effect of shock waves on the static source. At this time the power units (the four-chamber XLR-11 rocket engine — ed.) were cut and the airplane allowed to decelerate back to the subsonic flight condition. When decelerating through approximately .98 Mach number a single sharp impulse was experienced which can best be described by comparing it to a sharp turbulence bump."*

Yeager's matter-of-fact report belied the very real drama that had attended the flight.

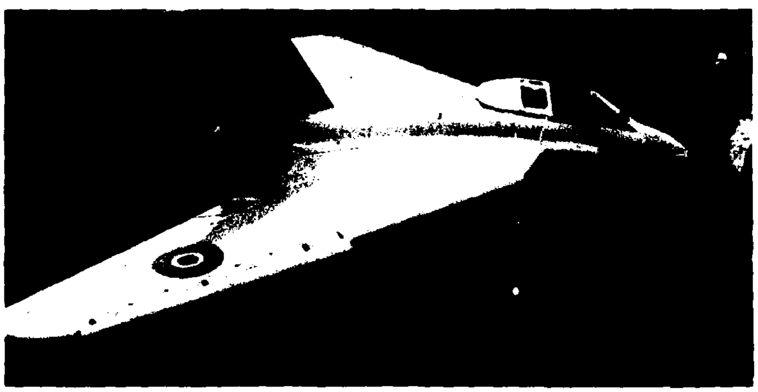


Figure 5: The de Havilland D.H. 108 Swallow represented an unsuccessful attempt to confront the challenge of transonic flight; deficiencies in stability and control led to the tragic death of test pilot Geoffrey de Havilland Jr in September 1946.

Photo courtesy British Aerospace Aircraft Group.

Figure 6: On October 14, 1947, test pilot Capt. Charles E.Yeager, USAF, became the first pilot to exceed the speed of sound, reaching Mach 1.06 (700 mph) at an altitude of 43,000 feet, flying the air-launched rocket-propelled Bell XS-1 research aircraft.

Photo courtesy Air Force Flight Test Center History Office, Edwards AFB

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Time off...

The Propulsion and Energetics Panel held ▶ their Fall 1988 Meeting in the Guildhall at Bath in the United Kingdom.

▲
Aerospace Applications Study Team No.28 met at the National Defence Institute in Lisbon in April.

▲
The Fluid Dynamics Panel take a break from their Fall 1988 Meeting in Çeşme, Turkey.

▲
NASA Ames Research Center, near San Francisco, was the venue of the Fall 1988 Meeting of the Guidance and Control Panel.

The Technical Information ▶
Panel met at the newly-refurbished Thermae Palace Hotel in Ostende in April.

▲
The Flight Mechanics Panel held their Fall 1988 Meeting at Edwards Air Force Base in California.

THE AGARD FAMILY

Air Vice Marshal PETER HOWARD, RAF, Chairman of the Aerospace Medical Panel from 1982 to 1984, was appointed a Commander of the Order of the Bath (CB) in the United Kingdom's 1989 New Year Honours List.

Colonel KNUD JESSEN, Chairman of the Aerospace Medical Panel from 1986 to 1988, was appointed Surgeon General of the Danish Armed Forces with the rank of Major General in 1988.

ELENI AXIOTOPOULOU, Greek National Coordinator since 1983, was married early in 1988 and gave birth to a son on 11 January 1989.

OBITUARY

General Ispettore UMBERTO FABI, Italian National Delegate from 1978 to 1982, died on 12 December 1988.

General Ispettore M.MARCONI, Italian National Delegate from 1983 to 1986, died on 1 February 1989. Since leaving the AGARD Family, General Marconi had been in charge of the purchasing of all military aircraft and stores for the Italian Air Force. He was also a member of the von Kármán Institute Technical Advisory Committee from 1983 to 1986. General Marconi was a very good friend to AGARD and our sympathy goes to his widow and family.

The death of **Mr THOMAS F.KEARNS,** Chairman of the Structures and Materials Panel from 1974 to 1976, was reported in the previous issue of 'Highlights'. This obituary was prepared by former colleagues on the Panel.

> Thomas F.Kearns was a member of the Structures and Materials Panel for approximately twelve years, and from the beginning established himself as a truly international scientist, providing a vigorous flow of ideas and enthusiasm for AGARD activities. He was in turn Chairman of the Working Group on High Temperature Corrosion of Aerospace Alloys, the Subcommittee on In-Situ Composites, the Subcommittee on Corrosion and the Policy Committee, and Chairman of the Panel from 1974 to 1976. He conceived and directed the activities of the R & D Subcommittee, which led to a substantial programme of cooperation between the stronger countries and the less developed countries of the Alliance before the National Delegates Board had implemented the Support to Nations Programme.
>
> Mr Kearns' hallmark was friendship and cooperation, and his success in technical matters was due in no small way to his ability to instill this spirit in the people around him. On retirement from full time professional service, Mr Kearns had had a long and illustrious career dedicated to the aeronautical sciences and to international cooperation. His colleagues of the Structures and Materials Panel, past and present, and his many friends in AGARD, would like to extend their condolences to Mrs Kearns and members of the family.

THIS REALLY IS THE END

The SMP Panel Song

In 1977, when the SMP held its Fall Meeting at Voss in Norway, Geoff Heath (UK) decided to further enliven the proceedings at the Panel Dinner by writing a song. Searching for a tune that would be well-known throughout the AGARD community, he hit on the one known as *Tannenbaum* in Germany, as *Mon Beau Sapin* in France, as *O Maryland* in the USA, and as *The Red Flag* in the UK. From those first few verses grew the tradition of the Panel Song (sung with great gusto from printed sheets and usually accompanied by the author at the piano or, on one memorable occasion, a borrowed piano-accordion!)

Geoff wrote verses for every subsequent SMP meeting until he became Panel Chairman in the Fall of 1984, when he announced that he could not be expected to write both the Panel Song and the Chairman's traditional after-dinner speech. The speech won!

Many of the verses cannot be appreciated without a lengthy expanation of the events of the meeting in question, but some will bear repetition, and a selection is published below.

Voss, Fall 1977:

We write reports to give the troops,
Who treat them with due deference;
We make up Ad Hoc Working Groups,
And give them Terms of Reference.
And then we get together, and
Hold meetings in the Netherlands
Or France or Greece or Germany —
We get around on SMP.

Florence, Fall 1978:

We told our wives: "We're leaving you;
We're off to Florence in the Fall."
They answered: "Then we're coming, too,
Or else you're going not at all."
And at the party Monday night,
They whispered: "Let's get one thing right:
You speak of her a lot, we know —
Which one is Supersonic Flo?"

Athens, Spring 1980:

At one time in this golden land,
The citizens came out *en masse*
To draw their circles in the sand
And learn from old Pythagoras.
So when we talk of lift and drag,
Remember what we owe Pythag;
An engineer is not much use
Without a squared hypotenuse.

Aix-en-Provence, Fall 1980:

To Aix we've come to spend the week —
Provincials ou Provencals;
And *parlons-nous de* cracks *et criques*
Et autres choses professional.
Ici l'eau fraiche runs through the mains
To take away our aches and pains;
Le boulanger such good bread bakes,
We'll take away some *pain* from Aix.

Çeşme (Turkey), Spring 1981:
(This was the first meeting for 'Danny' Coupry — a leading aeroelastician — as Panel Chairman)

We come from Greece and Germany,
From Denmark and the USA,
From Portugal and Italy,
From Belgium, Netherlands, UK
From Norway, Canada and France;
And Turkey, too, joins in the dance.
We sing all round the Bosphorus:
"We're rolling stones — no moss for us!"

The Turkish girls have elegance
And, though the weather's rather cold,
They like to do a belly dance
To help digestion, so we're told.
The Turkish men were pioneers;
With eagles' feathers, sweat and tears,
Although it sounds preposterous,
They flew across the Bosphorus.

In Autumn we'll be going Dutch,
Next Spring we'll all eat Brussels sprouts;
Toronto, Lisbon, London, such
Are our next *rendez-vous*, no doubts.
But then our thoughts will turn again
To Norway in the pouring rain:
Once more around the Bosphorus,
and then it's back to Voss for us.

Our Chairman's eyes are never shut;
He watches o'er the SMP.
His eyelids sometimes flutter, but
That's aeroelasticity.
He comes to rule us lesser men —
A Daniel in the lions' den,
So write in words of phosphorus
That Coupry *is* the boss for us!

Brussels, Spring 1982:

Though cheese is one of Brussels' treats,
Les fruits de mer come by the pound;
We jostle in the narrow streets
For *tout le monde* is mussel-bound.
Et on ne peut pas dire que we
Should not walk down to *la Vieille Ville*;
Quoi? Go without *nos moules?* No way!
In Brussels, mussels rule OK!

Toulouse, Fall 1984:

Mesdames, messieurs, encore we meet
Pour manger on this *mercredi*;
And once again *et tout de suite*
Nous chantons of the SMP.
Courage, mes braves, n'ayez pas peur,
But sing *très fort*, both him and her,
Et chantez ere your *voix* you lose:
Quel super news to choose Toulouse!

Le Panneau is a splendid *chose*,
Ses sujets cover ev'rything,
Et à la ronde the Panel goes
Aux pays dans the NATO ring.
So *maintenant* to France we come,
And this the *chanson* that we hum:
In ones and twos, *en onze et douze*,
Ah! restons-nous in *beau Toulouse!*

Mais l'heure is getting late, *je crois*,
So one more time before we go
Lift up *vos verres* and drink with *moi*
To *Structures et Matériaux*.
To *éprouvettes* and NDT
And aeroelasticity.
With *si bon* food and *si bon* booze
Say, who would choose to lose Toulouse?

Roy Maxwell (UK) added a valedictory stanza:

Our Panel song without a doubt
Has verses apt and comical;
For years Geoff Heath has turned them out
In numbers astronomical.
Our poet now lays down his pen,
But soon may pick it up again
If on to higher things he goes,
To entertain us all in prose.

A few verses appeared at the next meeting (San Antonio, Spring 1985) from the pen of the immediate Past Chairman, Bill Wallace (Canada), but thereafter the dinner venues were seldom suitable for community singing, and the Panel Song disappeared from the menu. However, at the meeting in Mierlo (Netherlands) in Fall 1988, Bill Wallace resuscitated the Song, his opening verse being

From round the world the SMP
Will talk of alloys stiff and strong;
We'll boast of castings defect-free,
We'll re-invent the Panel Song.
Now Geoff has gone at last to rest,
We know his song is still the best;
So sing again in Amsterdam
With Murray, Hans and Uncle Sam.

[The three characters mentioned in the last line are Messrs McConnell (Panel Executive), Forsching (Panel Chairman) and Venneri (Deputy Chairman) respectively.]

So it really wasn't the end after all; long may the SMP Song continue!